EVALUATION OF A LOW-COST EXTRUSION-COOKER FOR USE IN LESS DEVELOPED COUNTRIES

by

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SUMMARY

Preliminary tests of the Brady Crop Cooker indicate that this machine can be used to manufacture extrusion-cooked foods including full-fat soy flours and soy/cereal products. Extrusion-cooked grain products appear to have potential as low-cost, nutritionally improved foods and food ingredients for use in less developed countries (LDCs). These products seem suitable as ingredients in leavened bread, infant and weaning foods, blended food mixtures, and other nutritional food products. The machine might also be used to manufacture livestock feed and would be useful in programs aimed at promoting the production of less expensive meats, milk, eggs, and related animal products. Although not tested, the machine might also have application as a means for inactivating the fat-splitting enzymes in rice bran so rice bran oil can be recovered economically.

The Brady operates as a dry extruder so no addition of water or steam to the grain during processing is required. Heat for cooking is provided through conversion of mechanical energy from the drive motor--no additional heating is required. A 100 h.p. drive motor allows production rates of about 2,000 pounds per hour. The machine is currently priced at $3,125 (for tractor PTO drive) to $6,500 (complete with 100 h.p. electric motor). Throughput costs (processing costs, except raw materials) of less than $10 per ton should be feasible.

Additional evaluation is required to demonstrate conclusively that the machine can be utilized in LDCs. Further assessment should be directed to evaluating the properties of the products (nutritional, quality, functionality, and acceptability as food ingredients), making more refined cost analyses, determining potential markets for the products, and obtaining operating experience in LDCs.

Because of the low-cost of installation and operation of the machine, it seems appropriate for groups with interest in the machine to obtain units and undertake these evaluations in LDCs. Also it seems appropriate for one or more technical institutions with food and engineering capabilities to obtain units and undertake comprehensive evaluations of the machine including an evaluation of the potential for inactivating the fat-splitting enzymes in rice bran.

A. INTRODUCTION

Short-time, high-temperature cooking of grain products with extrusion processing equipment has become a well-established technology in the US. A wide variety of food, feed, and industrial grain products are currently manufactured using extrusion-cookers. The equipment available for this ranges from highly specialized units designed for production of specific commodities to extremely versatile units capable of producing a broad spectrum of extrusion-cooked products. A description of extrusion-cooking including the principles and potential product applications is given in Appendix A.

The purpose of this report is to evaluate a recently developed extrusion-cooker, the Brady Crop Cooker, and suggest how it might be used in food processing applications in less developed countries.

B. EQUIPMENT AND OPERATION

The Brady Crop Cooker was designed to provide farmers and small feedmill operators with a simple, inexpensive machine to cook whole soybeans for use in high energy animal feeds. Consequently, the Brady is characterized more as a farm implement than as a food processing machine. Even so, its use need not be limited to that of a farm implement. The Brady is far less expensive, simpler to operate, and easier to maintain than many machines designed and built specifically for the food processing industry.

1. Design

As in the case of other cooker-extruders, the essential element in the Brady is a compression screw. The screw is auger fed from a feed hopper mounted over the screw and the product is discharged from the screw through a variable annulus which acts as a flow restriction and which is a means of controlling cooking. The annulus consists of two conical surfaces through which the product must pass and which can be adjusted to open or close. No cutter or other means of subdiving or disrupting the product is used so the product must not be cohesive. Hydraulically driven augers are used to fill the feed hopper and remove product from the discharge to the compression screw.

No provisions are made for adding moisture to the stock in the machine; therefore, any adjustments in the moisture content of the feed stock must be made before conveying the stock to the extruder. Likewise there are no provisions for adding heat to the stock through steam injection or through heat exchange; all heat is generated internally by conversion of mechanical energy from the drive motor. Thus, the Brady requires no ancillary equipment such as steam generators, water supplies, driers (to remove excess moisture) and the like--its only requirement is for a drive motor.

The Brady should be powered with a 55-180 h.p. internal combustion (IC) motor or equivalent and should be driven at 540-1,000 r.p.m. The Model 206 Crop Cooker is designed to be driven using the power-take-off (PTO) from an ordinary farm tractor (see brochure, Appendix B).

Alternatively, the machine can be equipped with an electric motor as in the Model 2160 (see brochure, Appendix C). Either machine can be connected to a diesel or other stationary drive motor if special precautions are taken for speed control and shaft alignment. A general description of the design and construction of the Brady is given in the Operators Manual and Parts Catalog (Appendix D).

2. Operation

Operation of the Brady consists of (1) maintaining and adequate supply of feed material in the feed hopper, (2) controlling the feed rate of material into the compression screw with the metering auger (control valve), (3) adjusting the clearance in the discharge cones to control cooking temperature, and (4) removing the product with the discharge auger.

Generally, performance of the equipment is controlled through adjustments in the cooking temperature as shown on a temperature indicating gage. Temperature can be increased either by reducing the clearance between the discharge cones (at constant feed rate) or by increasing the feed rate (at fixed clearance between the discharge cones). Since predetermined temperatures can be achieved over a wide range of feed rates, the operator can generally select any feed rate up to the maximum permitted by the power available from the drive motor. In the case of whole soybean cooking, a 140 h.p. tractor or 100 h.p. electric motor allows a production rate of up to about 2,000 pounds per hour.

In order to prevent overcooking, the product should be cooled immediately after processing. This can be accomplished by distributing the product over a large area to allow the heat to dissipate naturally, or by using special cooling equipment. In either case, precautions must be taken to prevent the product from remaining at high temperatures.

3. Products and Product Limitations

Although the Brady is manufactured especially for cooking whole soybeans, its design makes it suitable for use in production of certain other items. In particular, the manufacturer has found that mixtures of soybeans and cereal grains (maize, sorghum, and the like) can be cooked with the Crop Cooker. However, these mixtures normally must contain at least 15-20 percent soybeans or sufficient oil so that the extruded product is not cohesive and does not form a continuous strip of exudate. Since the Brady does not have a cutting attachment, it is generally not suitable for cooking products which form continuous masses. However, whole grains such as sorghum can sometimes be processed if special care is taken by the operator.

The very high mechanical shear generated by the Brady's compression screw allows it to process whole, unground grains. Many other extruders require pregrinding of the feed stock. Consequently, whole soybeans mixed with whole corn and similar materials can be processed directly in the Brady without preparation. Also, preground feed materials, such as corn grits mixed with ground soy, can be processed. As a general rule, however, the feed stock must be free flowing so that the feed auger can function and not choke or plug.

Many extrusion-cooked products require addition of moisture to the feed stock either before or during extrusion to develop certain properties in the finished products. The feed to the Brady can be preconditioned with moisture, if desired, provided the required free-flowing properties of the feed stock are not affected. However, as mentioned earlier, there are no provisions for adding water or steam during extrusion-cooking. Nor is the Brady machine capable of creating product variations through alterations in residence time in the compression screw, variations in shear resulting from diverse screw designs, changing temperature gradients through indirect heating, and other effects resulting from the versatility designed into certain other extrusion-cooking equipment. The Brady is basically a fixed design machine with a relatively limited range of product capabilities.

4. Fixed Capital and Operating Costs

The cost for a Brady Crop-Cooker system and its operation can vary substantially depending on the type of operation involved. However, analysis of the fixed capital and operating costs for a "typical" operation can give an order of magnitude for actual costs and a basis for estimating costs under LDC conditions.

Fixed Capital Costs - The present costs of the Brady units, fob Des Moines, Iowa, USA are:

Model No.	Cost
206	$3,125
2160 (including 100 h.p. electric motor)	$6,500

Insurance, freight, and import duties on these units, of course, depend on where the unit is shipped and the particular import duties which are applicable. It seems unlikely, however, that a delivered unit including a drive motor of some suitable type would cost less than about $5,000 or more than about $15,000.

Installation of the unit with suitable housing, bins, and other accessories might vary from essentially no additional cost to as high as perhaps 3 times the CIF value of the equipment. Thus the total installed cost or fixed capital costs might be as low as $5,000 or as high as $45,000. The low figure might represent a simple operation equivalent to driving a Model 206 unit with an existing tractor in a farm operation; the high figure might represent a relatively complex factory-type operation with provisions for installation, for storing and handling raw materials and finished products, etc. A "typical" operation might have fixed capital costs of about $15,000.

Operating Costs - Operating costs for a "typical" system might include (a) fixed-cost charges for depreciation, taxes, and insurance, and (b) variable-cost charges for labor, supervision, overhead, power, and maintenance. Using the assumptions listed in Appendix E, total operating costs would be about $10 per ton of throughput (0.5¢ per pound). Depending on the location, percent of operating time used productively, and other factors, figures other than those listed in Appendix E can be used and closer estimates of operating costs reached. Costs of raw materials (including allocations for material losses and inventory costs)

and packaging costs should be added to arrive at a factory door cost of the product. Selling costs and profit should be added to arrive at an estimate of selling price.

C. EXPERIMENTAL EVALUATION

Because the Brady Crop Cooker represents a new development in low-cost extrusion-cooking, and because there is evidence of a need in low income countries for certain extrusion cooked products for nutrition programs, it seemed appropriate that the potential of the Brady machine be evaluated experimentally and the results of the evaluation made known in the LDCs. To this end, USDA acting on behalf of the Office of Nutrition, AID, made arrangements with Brady to carry out tests with the equipment (see Appendix F). Also, arrangements were made with Kansas State University, Archer Daniels Midland, and USDA's Agricultural Research Service, Northern Marketing and Nutritional Research Division, Peoria (ARS) to analyze the products made during these tests. 1/

The tests and product analyses which were made were not undertaken to provide a basis for a comprehensive evaluation of the machine. Rather, they were intended to furnish an overview of the machine's capabilities and provide sufficient information so that workers could consider possible applications in LDCs and determine if more extensive evaluations should be undertaken.

1/ The assistance and cooperation of Mr. Marvin Van Peursem, General Manager, Brady Division of Koehring Co., Drs. William Hoover and C. C. Tsen of Kansas State University, Drs. F. E. Horan and Akiva Pour El of Archer Daniels Midland Co., and Dr. Gus Mustakus of USDA/ARS are gratefully acknowledged.

1. Test Runs

All test runs were made with a Brady Model 206 Crop Cooker driven by a farm tractor equipped with a 120 h.p. diesel motor. The drive speed was in the range 600-700 r.p.m. for all runs. The test runs were used to produce samples of several extrusion-cooked products which might be of value as foods or food ingredients in LDCs. The raw materials used in the tests are listed in table I.

Table I.--Test materials

Material	Moisture	Protein	Fat
Whole soybeans*	6.5	39	19
Dehulled soybeans*	6.1	39	21
Degermed corn meal	10.3	8	1
Degermed corn meal (70%) mixed with dehulled soybeans (30%)	9.1	17	8

*The whole soybeans and dehulled beans were obtained from different sources; this difference in source probably accounts for the protein content not differing between whole beans and dehulled beans.

All of the materials were easily processed in trouble-free operations except the degermed corn meal. Operations with the corn meal were erratic and could not be stabilized to yield a uniform product. The cooked corn meal also formed a puffed, cohesive mass which would have required a cutter or sizing operation at the extruder discharge. As a result, it was concluded that the Brady is probably not suitable for cooking finely ground cereal grains without mechanical modifications.

Both the whole soybeans and dehulled soybeans were processed easily yielding a molten-like extrudate which, after cooling, solidified to form a granular product. As processing temperature was increased through the range from about 230° to about 300° F, the soybeans lost the usual raw,beany flavor and took on a toasted, nutty flavor. Also, as temperature was increased the product became more uniform; the product made at low temperatures contained many uncooked soybean pieces whereas that made at high temperature contained very few such pieces.

The corn-soy mixture also processed easily but formed a sheet-like product which broke into irregular chips at the extruder discharge. These chips retained a raw corn-soy flavor at temperatures below about 300° F. But, at temperatures above this level, the chips developed a pleasant toasted flavor.

Approximately 50 pound samples of each of the three materials were collected at several processing temperatures through the range of cooking conditions. Sample identification, operating conditions, and other test data are listed in table II.

Table II.—Sample identification and test conditions

Sample identification	Feed stock	Temperature °F	Throughput lbs./hr.
W-260	Whole soybeans	260	1130
W-278	Whole soybeans	278	1360
W-288	Whole soybeans	288	1480
D-240	Dehulled soybeans	240	1680
D-252	Dehulled soybeans	252	2080
D-283	Dehulled soybeans	283	2430
CS-310	Degermed corn mixed	310	1210
CS-330	With dehulled soy- beans	330	1320

2. Product Analyses

The primary reasons for cooking soybeans are to destroy the natural growth inhibitors and to remove the raw, beany flavors. At the same time, cooking must not be carried to the extent that nutritive value of the product is impaired. Unfortunately, analytical determinations to show these effects are not entirely definitive.

A common method of assessing the heat destruction of growth inhibitors in soybeans is by determining urease activity. Although urease activity *per se* is not important in human nutrition, reduction in urease activity has been found to correlate with removal of growth inhibitors so that if urease activity is reduced below a certain level by conventional processess, the growth inhibiting enzymes should be adequately inactivated. The urease level specified by the Protein Advisory Group (PAG) of the United Nations as indicative of adequate cooking is 0.30 or less. 2/ Also, it has been suggested by PAG that if urease activity is reduced below 0.02, cooking might be excessive and protein quality could be damaged. However, neither the upper level of 0.30 nor the lower level of 0.02 are considered absolutely definitive insofar as nutritional value is concerned. USDA specified a urease activity of 0.05 - 0.15 for defatted soy flours and grits and 0.05 - 0.50 for full fat soy flours used in blended foods and fortified commodities used in its donation programs.

2/ PAG Guideline No. 5. Soy Products. Protein Advisory Group of the United Nations System. March 29, 1972.

A second method which has been used for assessing the adequacy of heat treatment is the protein dispersability index (PDI). PDI decreases as heat treatment increases and it has been suggested that the PDI of properly heat treated soy should be in the range 12-25. 2/ As in the case of urease activity, the suggested range should not be considered absolutely limiting but rather a provisional guideline. Nitrogen solubility index (NSI) which is similar to PDI is also used as an indication of proper heat treatment. USDA specifies and NSI of 10-30 for defatted soy and 10-45 for full fat soy used in its donation commodities.

Another method of measuring adequacy of cooking is to determine residual trypsin inhibiting enzyme in the soy. Unfortunately, analytical methods for this have not as yet been standardized and limits on values have not been set. Therefore, it is particularly difficult to interpret the results of this determination.

Excessive heating of soy would be expected to damage protein and this affect might first be evident by loss of available lysine through reaction of lysine with sugar in the browning reaction. Therefore, excessive heating can be detected in some cases through measurement of available lysine. The available lysine content of raw soybeans is around 6.5 g/16 grams of nitrogen. The extent to which available lysine can be reduced is of course dependent on what loss in quality can be tolerated. However, it has been suggested that a minimum of 5 g/16 grams of nitrogen should be available. 2/

The urease activity, NSI, trypsin inhibitor, and available lysine content of the test samples were measured by ARS and are reported in table III.

Table III.--Analytical Values for cooked products

Sample	Urease activity (pH rise)	Nitrogen solubility index (%)	Available lysine g/16g. nitrogen	Trypsin inhibitor (percent destruction)	
				ARS	ADM a/
Whole soybeans					
W-240	1.5	41	6.4	15	70
W-252	0.4	25	6.5	55	93
W-283	0.08	15	6.4	85	100
Dehulled soybeans					
D-260	2.0	59	6.0	9	50
D-276	1.6	41	6.4	12	70
D-288	0.18	20	6.4	60	99
Degermed corn/dehulled soy					
CS-310	0.03	6	4.2	91	96
CS-330	0.00	8	4.4	94	100

a/ ADM results were obtained from a separate set of samples.

As can be seen from table III, the urease activity of whole and dehulled soybeans at the moisture content used can be reduced to 0.02 - 0.30 (the range suggested by the PAG) by cooking at temperatures over about 250° F and under about 290° F, but particularly at temperatures around 280-285° F. Some difference in the effect of temperature can be noted between whole and dehulled bean products with dehulled beans requiring a somewhat higher temperature than whole beans. The NSI results shown in table III also indicate that satisfactory cooking

will result from temperatures in the range 250-290° F with temperatures in the higher end of the range giving better results. Measurements of available lysine, as listed in table III, show essentially no loss of available lysine throughout the range of processing temperatures and therefore indicate no adverse effects on the nutritional value of the products due to cooking.

3. Product Use Tests

Of the potential applications for the extrusion-cooked products described in the previous sections, very few lend themselves to simple testing. (Use of extrusion-cooked whole soybeans as a feed ingredient has already been evaluated 3/ and was not tested further as a part of this study). Food uses of the products by themselves or as fortificants for food staples or as ingredients in other foods, can not be properly tested without a great deal of effort. Consequently, with the exception of an evaluation of the cooked soybean products as protein fortificants in bread and cookies, no attempt has been made to experimentally evaluate the use of the products in food applications. However, based on the analytical values reported in table III, it is clear that the products should have potential as food and food ingredients.

In recent years, a number of studies have been undertaken to find means of adding protein concentrates such as soy flour, fish protein concentrate, and others to leavened bread. As a result of these studies

3/ Proceedings Arkansas Formula Feed Conference, Univ. of Arkansas, Fayetteville, Arkansas. Sept. 28-29, 1972.

it has been found that very small amounts of certain chemical additives enable bakers to incorporate significant amounts of soy and other proteins in bread without seriously damaging bread quality. 4/ This procedure can result in finished bread products with up to 50 percent or more additional protein and greatly improved protein quality and represents an important breakthrough in using bread as a means of improving protein intake. However, a major obstacle to use of the procedure is the lack of low-cost indigenously produced protein concentrates with which to fortify bread. Extrusion cooked soy represents a potential solution to the problem.

Samples of the cooked whole and dehulled soy prepared during this evaluation were tested as fortificants in bread at KSU. Results on these tests were encouraging. Representative data are listed in table IV.

Table IV.--Bread baking results

Sample	Level of addition (% of flour)	Sodium stearoyl lactylate (%)	Average loaf value (cc)	Specific loaf value	Grain score
Standard	0	0	2700 (min.)	6 (min.)	5 (min.)
W-288	12	0	2375	5.47	5
W-288	12	0.5	3125	7.28	9
D-283	12	0.5	3075	7.02	9

The data show that addition of the cooked soy at the 12 percent level and with the 0.5 percent sodium stearoyl lactylate (SSL) yields

4/ Tsen, C. C. et al. High Protein Breads, Bakers Digest. 45: No. 2 20-23. 1971.

bread with satisfactory volume and grain whereas soy addition without SSL led to excessive reduction in volume and borderline grain. In addition, a number of baking tests were conducted to prepare cookies from wheat flour fortified with 12 percent of the cooked whole and dehulled soy samples. Baking results demonstrated that acceptable cookies could be prepared from these soy samples used as fortificants. The KSU staff also noted that, unless the cooked soy from the Brady was ground, the soy particles caused discoloration spots in the bread crumb and crust. Roller-mill grinding of the soy to pass a 36 mesh sieve eliminated this effort. KSU also reported that the cooked soy crumbled easily during grinding and, even though it contained a high oil content, could be sifted without plugging the sieves. Thus, it might be concluded that the cooked soy can, if necessary, be ground and/or classified to produce products for various food applications.

D. CONCLUSIONS AND RECOMMENDATIONS

The results of the evaluation of the Brady Crop Cooker suggest that this machine is likely to have application in low income countries for the manufacture of extrusion-cooked products for use in food and feed. Applications which appear promising based on limited tests include:

1. Extrusion-cooked whole or dehulled soybeans for use as (a) protein fortificants for leavened bread, (b) ingredients in blended-foods (such as CSM-type products), infant foods, and similar formulated food products, and (c) ingredients in animal feeds.

2. Extrusion-cooked <u>mixtures of soy and cereal</u> for use as precooked food or feed mixtures.

   Although not tested, use of the machine to inactivate rice-bran enzymes (to prevent degradation of rice bran oil) might also be feasible.

The low capital costs, high throughput, and simplicity of operation of this extrusion-cooking equipment suggest that it would be particularly useful in low income countries. The equipment appears to be very well suited for small-scale manufacturing operations. It also appears suitable for use in large-scale factory operations or, at the other extreme, as a basic grain cooking machine for farm or village operation. Because the cooked products have potential value in both food and feed applications, the machine seems well suited for an integrated food/feed manufacturing operation.

Throughput costs, estimated at around $10 per ton, are relatively low compared with other methods of grain cooking. Equipment costs and fixed capital costs are also especially low for continuous, high-throughput food processing operations. Furthermore, the adaptability of the machine to use in LDCs appears to be excellent--the simple design and ease of control as well as the suitability of the machine for tractor or electric power make it especially attractive.

On the other hand, the Brady machine has certain limitations or uncertanties which should be taken into consideration. The major uncertanties or limitations are:

1. Markets for extrusion-cooked products have not been developed in many LDCs and therefore outlets for the products from the Brady machine are not assured.

2. The Brady has not been operated under LDC conditions and, therefore, appropriate field experience necessary to demonstrate feasibility of operations is not available.
3. The Brady is not as versatile as certain other extrusion-cookers and appears to be unsuitable for manufacture of some of the usual extrusion-cooked products such as degermed corn meal products. From a conservative point of view, application of the Brady machine might be considered as being limited to soybeans or mixtures of cereal with a substantial amount of undefatted soy. Thus, the Brady can only be given immediate consideration in those areas where soybeans are grown or can otherwise be made available for processing.
4. The need for cooling the product (to prevent over cooking) and methods of cooling have not been sufficiently considered to know if cooling problems exist and, if so, how such problems can be solved.
5. The nutritional quality and acceptability of Brady-cooked products have not been fully demonstrated. Normally, products of this type should be subjected to both animal and human tests to establish nutritional value and acceptability.

Taking into consideration the potential value of the Brady Crop Cooker in LDCs and also its apparent limitations and the uncertainties remaining after the present exploratory evaluation, the following recommendations are offered.

1. <u>The Brady Crop Cooker should be subjected to more intensive testing as a means of cooking soybeans and soy/cereal mixtures</u>. This work should

be undertaken by institutions with capabilities for developing food products and processes in LDCs. Ideally, testing should be undertaken in these nations and both technical and market evaluation activities should be undertaken concurrently. Market and financial analyses should be made to estimate the size of the potential market for products, the value of products in those markets, and the potential return on investment or profitability for manufacturers. In those countries where interests exist but testing capabilities do not, testing might be undertaken by a qualified U.S. institution such as Kansas State University. All such testing should emphasize evaluation of the Brady products in food applications with special attention given to acceptability, nutritional value, and replicability of results.

2. The suitability of using the Brady Crop Cooker to inactivate the fat-splitting enzymes in rice bran should be investigated. This investigation should include assessment of both technical and economic aspects of this potential application.

Recognizing that the amount and quality of information required to reach decisions varies, some decision-makers might conclude that sufficient technical, marketing, and financial information is available to proceed immediately with installation and operation of machines. Considering the low cost of the machine and the relative ease of installation and operation, this decision seems appropriate in certain countries, especially those countries where utilization of soybeans is under study.

APPENDIX A

EXTRUSION COOKING

Principles of Extrusion Cooking

Extrusion-cooking is a continuous process in which materials are heated and mechanically worked in a compression screw and then extruded from the screw through a die or other restriction. Generally, the materials reach relatively high temperatures in the screw (250-350° F) but remain at those temperatures for only a few seconds. The material generally is heated and worked to the extent that it becomes plastic during processing and sometimes expands or puffs as moisture contained in the material flashes to steam when the material emerges from the die.

Heat for cooking is supplied through conversion of mechanical energy to heat through friction in the compression screw, or injection of steam into the material during processing or transfer of heat from a heat source through the screw or barrel, or a combination of these mechanisms. The moisture content of the material can be adjusted by preconditioning the stock before processing or by addition of steam or water to the material during processing; generally the moisture content of grain materials is adjusted in the range 10-30 percent. By proper design and operation of the extrusion equipment and by controlling the time and temperature of cooking and the amount and intensity of working of the stock, the size, shape, texture, and other properties of the product can be modified. Selection of equipment and conditions of equipment operation can lead to a broad range of cooking effects and product variations.

Products

A major application of extrusion-cooking has been in the manufacture of cooked cereal grain products. 5/ Products in this group range from familiar food products such as cheese coated corn curls and other puffed snacks to gelatinized cereal flours for industrial purposes such as those used in foundry core binders and oil well drilling muds. 6/ Also included in this category are products such as formulated pet food products and the processed corn meal (PCM) used in the manufacture of corn-soy-milk (CSM). Extrusion-cooked cereal products vary from large pieces to very fine flours; they vary in texture from soft porous chunks to hard dense pellets; and they differ in value from expensive consumer oriented foods to very inexpensive low-margin commodities. The entire spectrum of this group of products is produced in large quantity in the US with extrusion-cooking equipment of one type or another.

5/ Smith, O.B., Extrusion-Processed Cereal Foods (Protein-enriched cereal Foods for World needs, Max Milner ed., AACC, pp. 140-153). 1969.

6/ Burgess, H.M. et al, Binder Product and Process. US 3,159,505 Jan. 6, 1970.

A second category of extrusion cooked grain products are the textured protein products (except those made by the spinning process). Textured proteins are created by controlled denaturation of protein, especially soy protein, in extrusion-cooking machines to produce chewy, structured bits and pieces. 7/ By incorporating flavors and colors, the products can be made to resemble meat, poultry, and other natural products with a chewy texture. Although these products are a relatively recent development of extrusion-cooking technology, they are manufactured in appreciable quantity by several US companies.

A third category is those products in which heat labile enzymes are inactivated by extrusion-cooking. A notable example of this application is the inactivation of the growth inhibiting enzymes in soy; a number of extrusion-cooking systems are currently in commercial use to process soy for this purpose. 8/ A second application of this type, although not one which is practiced commercially, is the inactivation of fat splitting enzymes in rice bran to render the bran stable and allow time for storage and transportation to oil extraction plants. 9/

Additional applications of cooker-extrusion equipment outside grain processing such as plastic forming, rubber dewatering, etc. are also known and practiced commercially.

Equipment

The diversity of extrusion-cooking equipment is extremely broad. Although many machines have been built for specific product applications, some of the equipment is quite versatile. For example, although certain machines have been designed specifically for the purpose of making puffed snacks and certain other machines have been designed only to cook soybeans, still other machines are sufficiently versatile to make snacks, cook soybeans, and serve a variety of other purposes. In addition, as new products have been conceived, technologists have adapted or modified the various machines to perform new functions. For example, plastic extruders have been found to be effective in making textured protein products and cereal cooking machines have been used to inactivate enzymes.

One of the consequences of the diversity of extrusion-cooking equipment is that the proper selection of a machine for a given task is not simple. Since it is usually possible to make a given product with any of several different machines, but selection of one machine rather than another could result in limitations on versatility, capacity, capital requirements,

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7/ Atkinson, W.T., Meat-Like Protein Food Product. US 3,488,770. Jan. 6, 1970.

8/ Mustakus, Gus C. Full-Fat Soybean Flours by Continuous Extrusion Cooking (World Protein Resources, Advances in Chemistry Series No. 57, ACS pp. 101-108) 1966.

9/ Baer, S. et al. Pretreatment of Oleaginous Plant Materials. US 3,255,220 June 7, 1966

or operating costs, it is usually appropriate to make an analysis of alternatives before selecting the "best" machines for the job. Such an analysis obviously should take into consideration the capabilities, costs, advantages, and disadvantages of each alternative. Among the spectrum of extrusion-cooker systems will be found units ranging in capacity from several pounds to several thousand pounds per hour, ranging in cost from a few thousand dollars to over $100 thousand, and ranging in complexity from those requiring highly skilled operators to those for which operators can be trained in minutes.

Applications in Less Developed Countries

A number of applications of extrusion-cookers in LDCs have been suggested. Although some of these applications are related to industrial non-food applications, many have a direct bearing on production of foods and food ingredients. These latter applications include:

1. Production of full fat soybean flour from dehulled soybeans--for use as an ingredient in weaning foods and in blended foods (such as CSM), as a beverage base, and as a fortificant in wheat flour, bread, and other food staples.

2. Production of blended food products--through extrusion-cooking of cereal grain products or mixtures of cereals, protein supplements, and nutrient concentrates.

3. Production of puffed snacks and especially fortified snack products--such as protein, vitamin, and mineral fortified puffed corn and rice products.

4. Production of textured protein products--such as the textured soy proteins used as meat extenders and meat replacements.

5. Production of enzyme-inactivated rice bran--to stabilize rice bran, allow it to be stored and transported to oil extraction facilities and extracted, and thereby increase the production of edible vegetable oils.

6. Production of enzyme-inactivated whole soybeans--for use as a high energy, high protein quality ingredient for animal feeds.

Although not all of these applications would be expected to be practical in every LDC, and none of them might be practical in certain areas, the range of opportunities and the potential demand for products suggest that application of extrusion-cooking in one form or another ought to be at least considered in all LDCs.

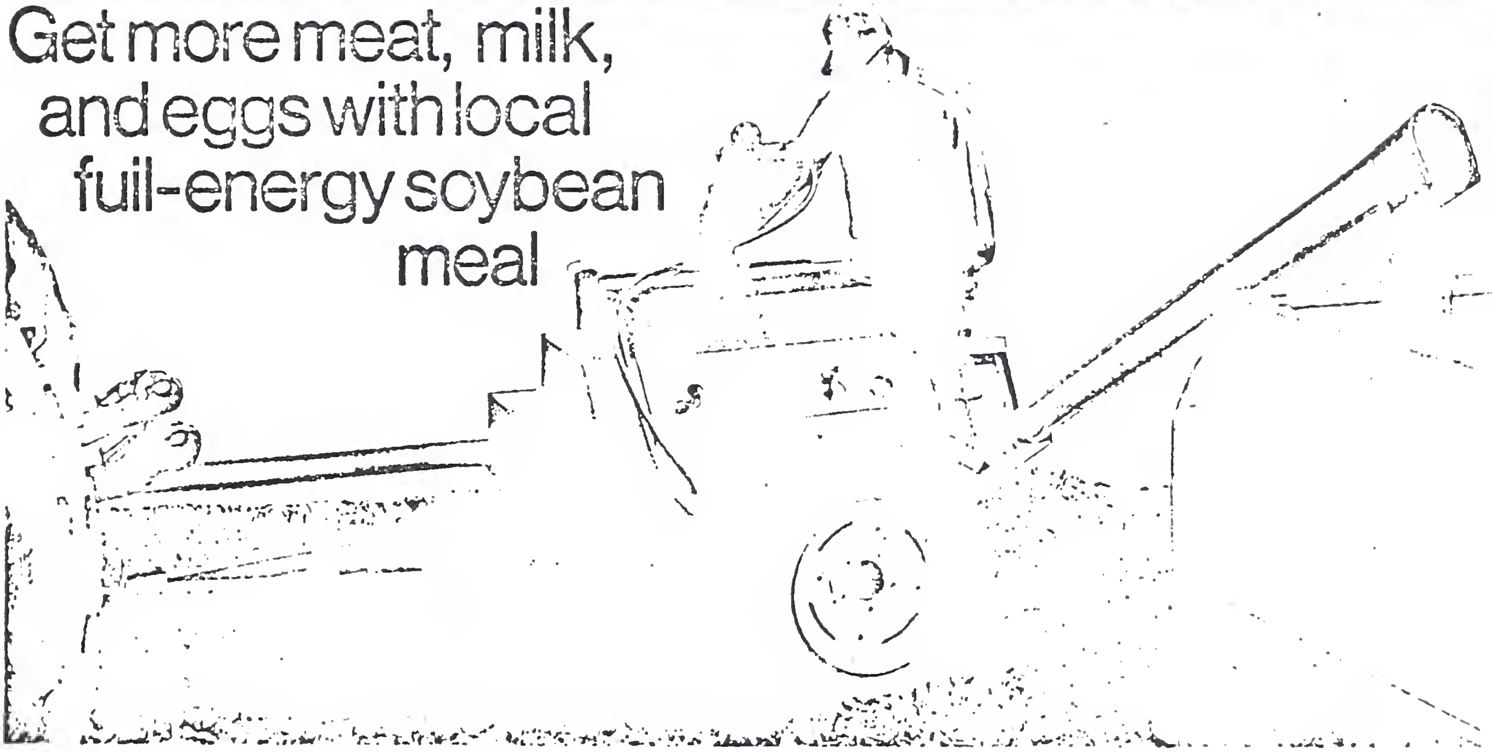
KOEHRING
Farm Division

BRADY

206 CROP COOKER

APPENDIX B

Get more meat, milk, and eggs with local full-energy soybean meal



The Soybean

One of the oldest crops grown by man, the soybean, was introduced to this country in about 1800. Today, over one billion bushels of soybeans are grown annually in the United States. Acreage has doubled in the last ten years.

The Technology

The feeding of raw soybeans, which contain a toxic growth inhibitor, was a problem until recently. The inhibitor ties up the enzyme, trypsin, which retards normal growth by causing incomplete assimilation of the protein. It is inactivated by cooking. Cooking also debitters and removes the "beany" flavor, rendering a very palatable, valuable feed.

Brady uses the extrusion method of cooking the soybean, which de-activates the growth inhibitor, retains the rich oil, and produces a full-energy soybean meal. The end results are less feed requirement, lower costs, faster weight gain and greater profits. This new technology opens another market to soybean growers: soybeans marketed through livestock.

The Advantages

- Lower livestock feeding, cost, greater profit.
- Improved utilization of the high energy fat.
- Full-energy soybean meal, with the oil left in, is a natural source for those factors essential for livestock maintenance, growth, reproduction, lactation
- Aids vitamin stabilization, keeps vitamins in feed.
- Soy lecithin, a preservative in full-energy soybean meal, deters rancidity, helps keep feed fresh and palatable.
- Lecithin provides 2¼ times as much energy as a carbohydrate.

Research by leading universities, independent laboratories and the U.S.D.A. has proven the feeding, cost and profit benefits of full-energy soybean meal. Now, Brady provides the low-cost mechanical means to produce this valuable meal to turn local soybeans into higher profit meat, milk and eggs.

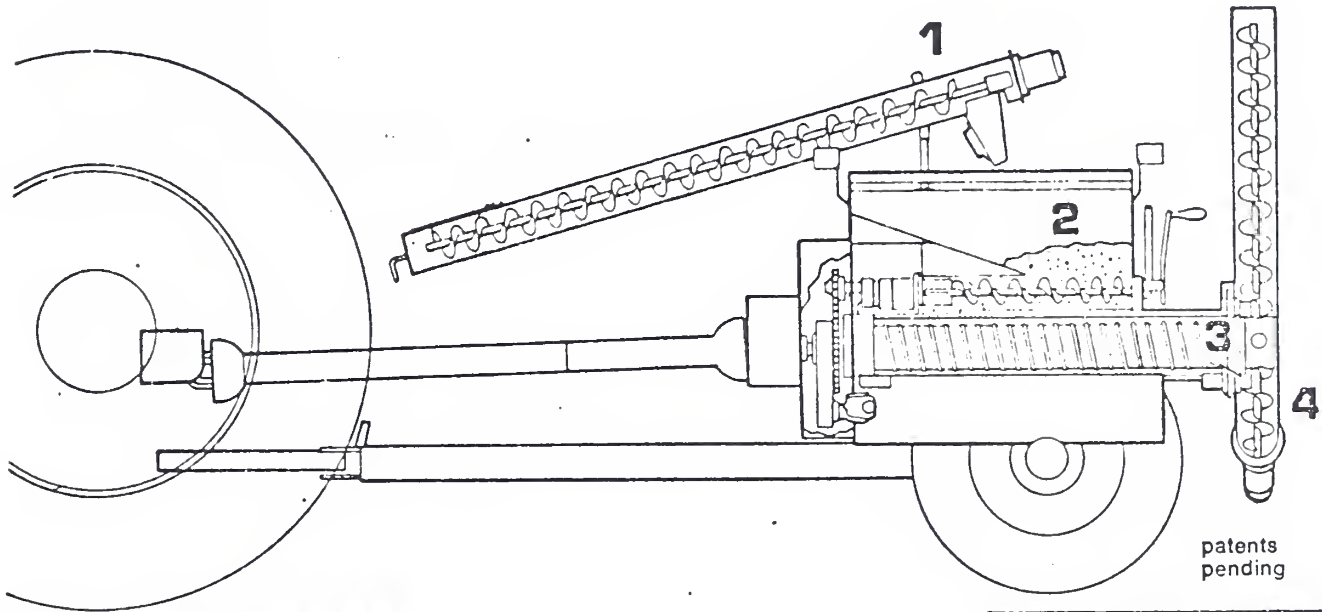
Let's look at the many advantages of the Brady Crop Cooker.

- Portable PTO powered (exclusive).
- Use your own tractor power.
- No electricity or LP gas required.
- Lends itself to multi-farm use.
- Adapts to existing storage facilities.

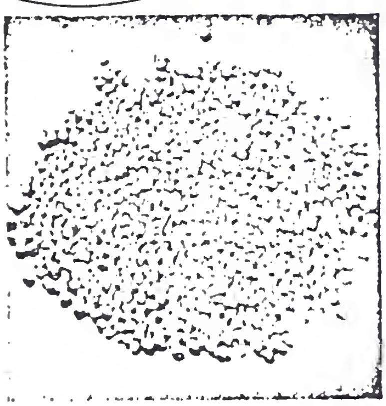
What do owners of Brady Crop Cookers say:

- "Better feed quality control."
- "Fresher feed."
- "10% better feed utilization."
- "Savings in excess of $50 per ton."
- "More rapid gains."
- "I've kept this meal for months with excellent

Produce up to 2000 pounds of full energy meal per hour

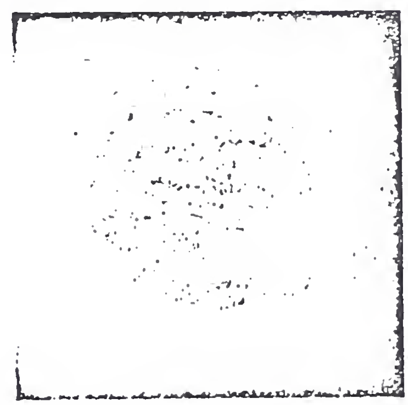


patents pending



Raw soybeans from existing storage facilities, ready for extrusion process.

The Brady Crop Cooker fits into your bin system. In (1.) above, adjustable intake auger, hydraulically driven, carries raw soybeans from storage bin into (2.), hopper. By variable hydraulic control, soybeans are metered into (3.), extrusion chamber. Cooking temperature and processing rate are adjustable. Cooked meal, ready to feed, is conveyed from the machine by the hydraulically driven discharge auger (4.). Highly compact and portable, the Brady Crop Cooker can be towed to the soybean bin site. PTO powered, it can also be coupled to other power sources.



Extruded soybean meal, full-energy and profit producing, with all valuable oil remaining.

BRADY CROP COOKER SPECIFICATIONS

PROCESS: Extrusion heat destroys soybean growth inhibitor and ruptures oil cells for improved feed utilization.
FILL AUGER: 8′ long with magnet and adjustable intake.
DISCHARGE AUGER: 8′ long, adaptable for right or left discharge.
AUGER DRIVES: Self contained hydraulic system.
POWER REQUIREMENT: 55 to 180 H.P. (one model).
APPROXIMATE CAPACITY: 800 pounds per hour @ 55 H.P.
1400 pounds per hour @ 90 H.P.
2000 pounds per hour @ 150 H.P.
TRACTOR PTO SPEED: 540 R.P.M. or 1000 R.P.M. (one model)

WEIGHT: 853 pounds
FOR TRANSPORT: WIDTH — 5 feet
LENGTH — 11½ feet
HEIGHT — 10 feet

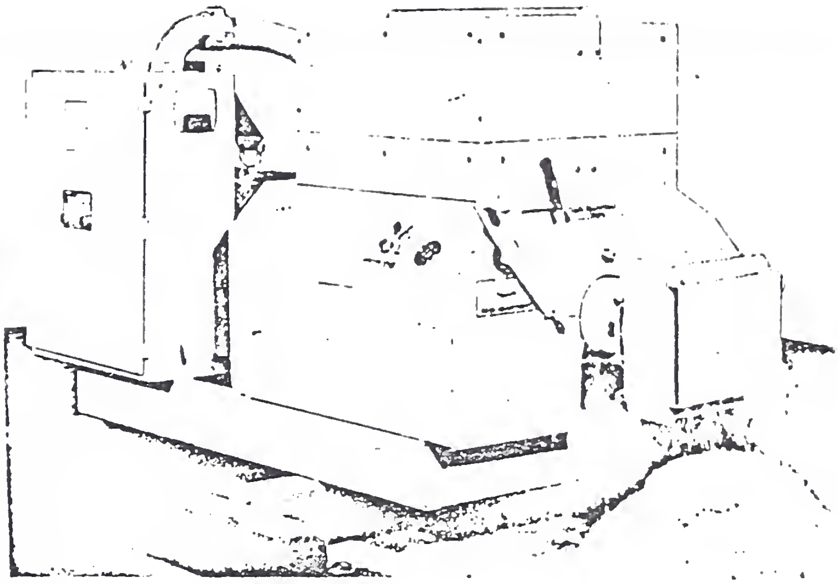
APPENDIX C

KOEHRING

Koehring

2160 EXTRUDER/ COOKER

Take advantage of the fast growing feed protein market with the Koehring extruder/cooker



THE TECHNOLOGY

Heat processed soybeans are increasing in importance as a major source of protein in livestock rations. Processing is necessary because the raw soybean contains a toxic growth inhibitor which ties up the enzyme trypsin. Causes incomplete assimilation of the protein, retarding normal growth.

The Koehring method of processing soybeans by extrusion, deactivates this toxic. Also de-bitters and removes the "beany" flavor and releases the soy lecithin which deters rancidity. This helps keep the soybean meal fresh, palatable and rich in oil, for a high energy protein meal. The heat build up caused by extrusion also ruptures the cell walls of the bean, making nutrients more available for increased digestibility. A total of 92% digestibility of nutrients for hogs.* The end results are less feed requirements, lower costs and faster weight gains.

Research by leading universities, independent laboratories, the U.S.D.A. and many users has proven the feeding, cost and profit benefits of high-energy soybean meal. Now Koehring provides the low-cost mechanical means to produce this valuable meal. The Koehring Extruder/Cooker opens a new market for feed and grain dealers.

USE THE 2160 EXTRUDER/COOKER TO:

- Add a new service for your customers
- Assist in controlling total feed formulation
- Enhance feed quality
- Provide fresher feed
- Manufacture your own supplement
- Increase vitamin-mineral sales

PROVIDE YOUR CUSTOMERS WITH:

- Lower feed costs
- Faster gains
- Healthier animals
- Less feed requirement
- Higher milk and butterfat production

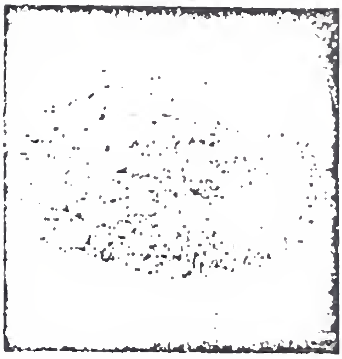
*Ingredient analysis table (1971) from Feedstuffs year book 1971-72 issue.

OPERATION

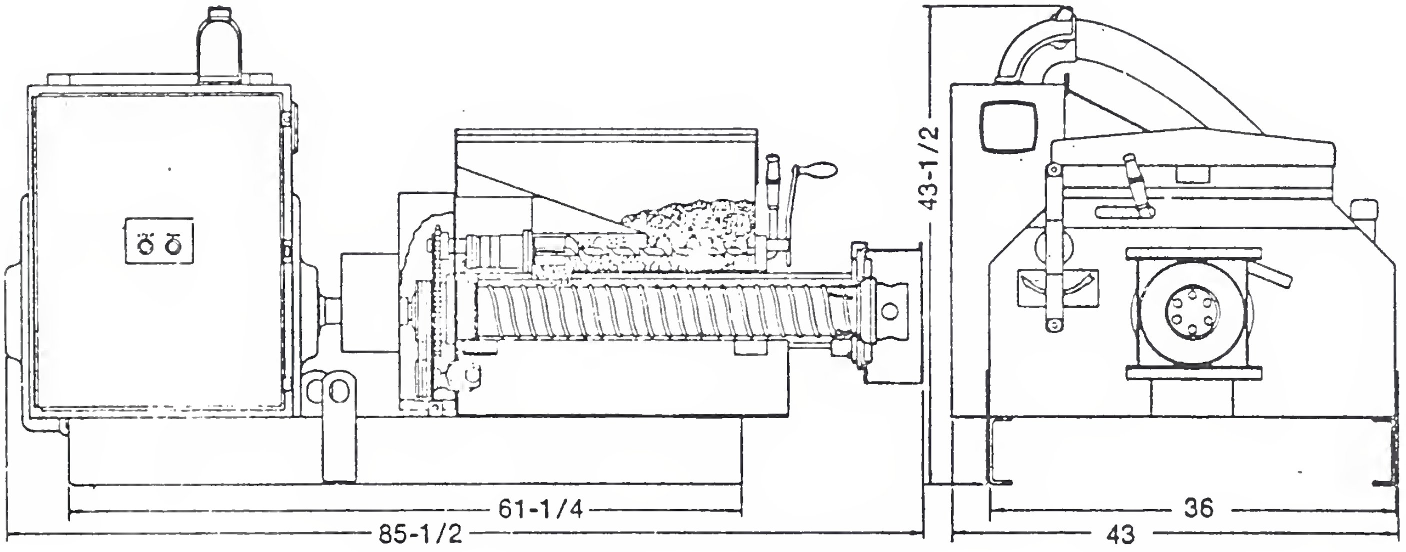
The Koehring Extruder/Cooker is a compact, complete unit. Because the extrusion method provides the heat necessary to cook the beans, LP gas, a steam boiler or other external heat sources are not required. All that's necessary is three phase service to operate the electric motor, and provisions to move soybeans to the machine and remove the full energy meal.

This machine is easily operated by just two controls. A crank regulates the extruder die opening and cooking rate and a lever precisely controls input of soybeans. Minimum supervision is required and all gauges can be checked at a glance. At shutdown the Koehring Extruder/Cooker is self-cleaning. Disassembly is not required.

1. Raw soybeans ready for extrusion process.



2. High-energy, extruded soybean meal with all valuable oil remaining.



STANDARD FEATURES

- Automatic push button reduced voltage starter.
- Thermal overloads to protect motor.
- Ammeter to monitor power consumption.
- Temperature gauge.
- Vinyl hopper cover.
- Electric motor power source.
- High capacity self contained hydraulic system.
- Skid mounted.

Koehring Extruder/Cooker Specifications

Extruder/Cooker

Weight: 1850 pounds
Overall Length: 85½"
Overall Width: 43"
Overall Height: 43½"
Injector Drive:
Variable Hydraulic

Electric Starter

Automatic Reduced Voltage.
Push Button Switch.

Power Source

Electric Motor: 100 H.P., 3 Phase, 460 Volt (380 Volt, 50 Hertz available).
Running Amperage: 125 amps @ 460 volts.
Protected by Thermal Overloads.
Large, easily viewed Ammeter.
No LP Gas, Boiler or External Heat Source Required.

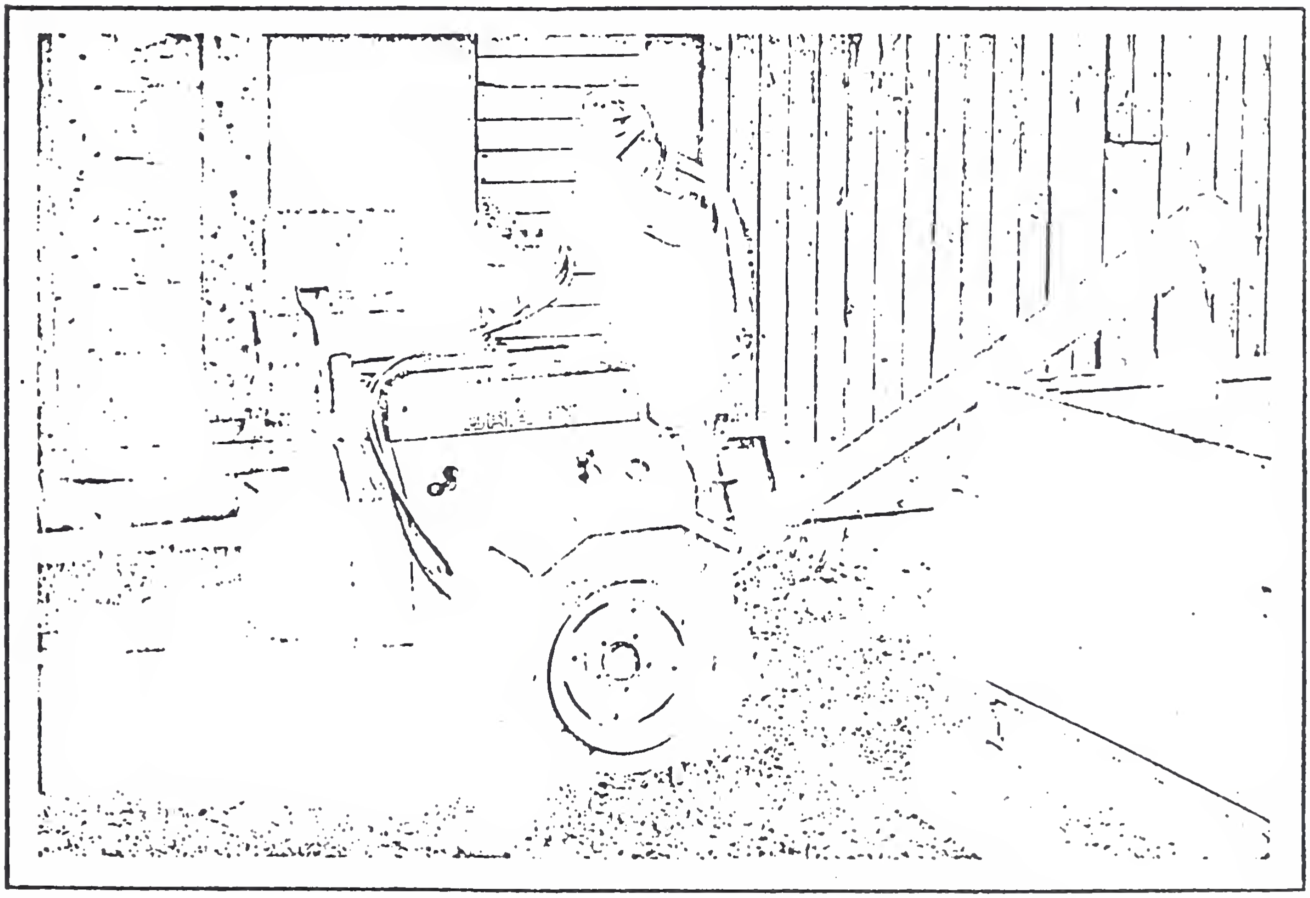
WE RESERVE THE RIGHT TO AMEND THESE SPECIFICATIONS AT ANY TIME WITHOUT NOTICE. THE ONLY WARRANTY APPLICABLE IS OUR STANDARD WRITTEN WARRANTY. WE MAKE NO OTHER WARRANTY, EXPRESSED OR IMPLIED

KOEHRING

APPENDIX D

BRADY

206 CROP COOKER



OPERATORS MANUAL
PARTS CATALOG

KOEHRING

Koehring
Farm Division
Des Moines, Iowa 50305

TO THE PURCHASER

This manual provides instructions with essential information for operation, adjustments, setting-up and repair parts for your new Brady 206 Crop Cooker. Study this manual carefully and keep it in a safe place for future reference. It will help you obtain greater performance from your machine.
The Brady 206 Crop Cooker has been designed for long useful service. It features integral hydraulic system and hydraulic motor driven auger conveyors.
Date of Purchase ____________________
Serial Number ____________________
The serial number is located on the right side shield in front of the fender.
Right and left reference is determined by standing behind the machine, facing the direction of transport.

CONTENTS

SPECIFICATIONS 3

ASSEMBLY & PREPARATION 3

SAFETY SUGGESTIONS 3

OPERATION
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- Transporting 5
- Cone Adjustment Brake 6
- Extruder Rotor Removal 6
- Belt Tension 6
- Lubrication 7
- Hydraulic System 7

OPERATING TIPS 8

PART NUMBER REFERENCE 8

PARTS IDENTIFICATION
- 44 R P.T.O. 540 and 1000 R.P.M. 9
- Fill Auger, Discharge and Extension Augers 10,11
- Frame and Cylinder 12,13
- Hydraulic System 14,15

WARRANTY 16

SPECIFICATIONS

PROCESS: Heat from extrusion process destroys soybean growth inhibitor.
FILL AUGER: 8 feet long with magnet and adjustable intake.
DISCHARGE AUGER: 2 feet long, adaptable for right or left discharge.
EXTENSION AUGER: 8 feet long, easily removable for transport.
AUGER DRIVES: Self contained hydraulic system.

APPROX. CAP.: 800 pounds per hr. at 55 H.P.
1400 pounds per hr. at 90 H.P.
2000 pounds per hr. at 150 H.P.

TRACTOR P.T.O. SPEED: 540 R.P.M. or 1000 R.P.M.
WEIGHT: 850 pounds.
FOR TRANSPORT: Width - 5 feet; Length - 10½ feet; Height - 4 feet
HYDRAULIC SYSTEM: 2000 psi, 5 gpm at 1000 rpm P.T.O.

ASSEMBLY & PREPARATION

The BRADY 206 CROP COOKER is pre run and tested before shipment from the factory. The complete machine consists of two shipping bundles, a base machine and an auger-PTO crate.

To set up the machine, install tires on the wheels provided and infalte to 12 psi only. Install the tires to the base machine and remove the front shield. Install the PTO to the rotor shaft of the extruder. Before replacing the front shield place the sheave wrench found in the parts bag over the hook on the right side of the extruder barrel. Also install the auger saddles found in the hopper to the front and rear of the hopper. Replace the front shield and place the front yoke of the PTO over the pin near the front of the tongue. It may be necessary to adjust cones for maximum clearance to install PTO over pin. Place one hook on the rubber strap in one of the two holes provided near the front of the tongue and crimp the hook together so as not to loose the strap. This strap is placed over the PTO and hooked in the other hole to retain the power take off unit in transit.

To install the fill auger, place the rubber cushions found in the parts bag in the saddles and place the fill auger in the left pair of saddles with the hyd. motor toward the front of the machine. Insert the lockpins in both lockpin ears. Remove the two 3/8 pipe plugs that are located at the front of the left fender and install the two hydraulic hoses. Connect the top hose to the top hole of the fill auger motor and the bottom hose to the bottom hole.

To install the discharge auger, remove the two hinge rods in the rear swivel bracket, position the discharge auger in place and re-insert the hinge rods. Each hinge rod is kept in place by a hair pin clip. With the discharge auger in a vertical position connect the hose from the control valve to the right hole and connect the other hose to the left hole. If these hoses should be connected wrong the discharge auger will run backward and the hoses must be switched.

To install the extension auger, swivel the short discharge auger to a position just above horizontal, then slide the support pipe of the extension auger into the ears of the discharge auger holding the outer end up untill fully engaged then lower the extension auger into place. It may be necessary to loosen the bolt through the extension auger ears and adjust the support pipe for proper fit of extension and discharge augers. For transport the extension auger is carried in the right pair of saddles similar to the full auger.

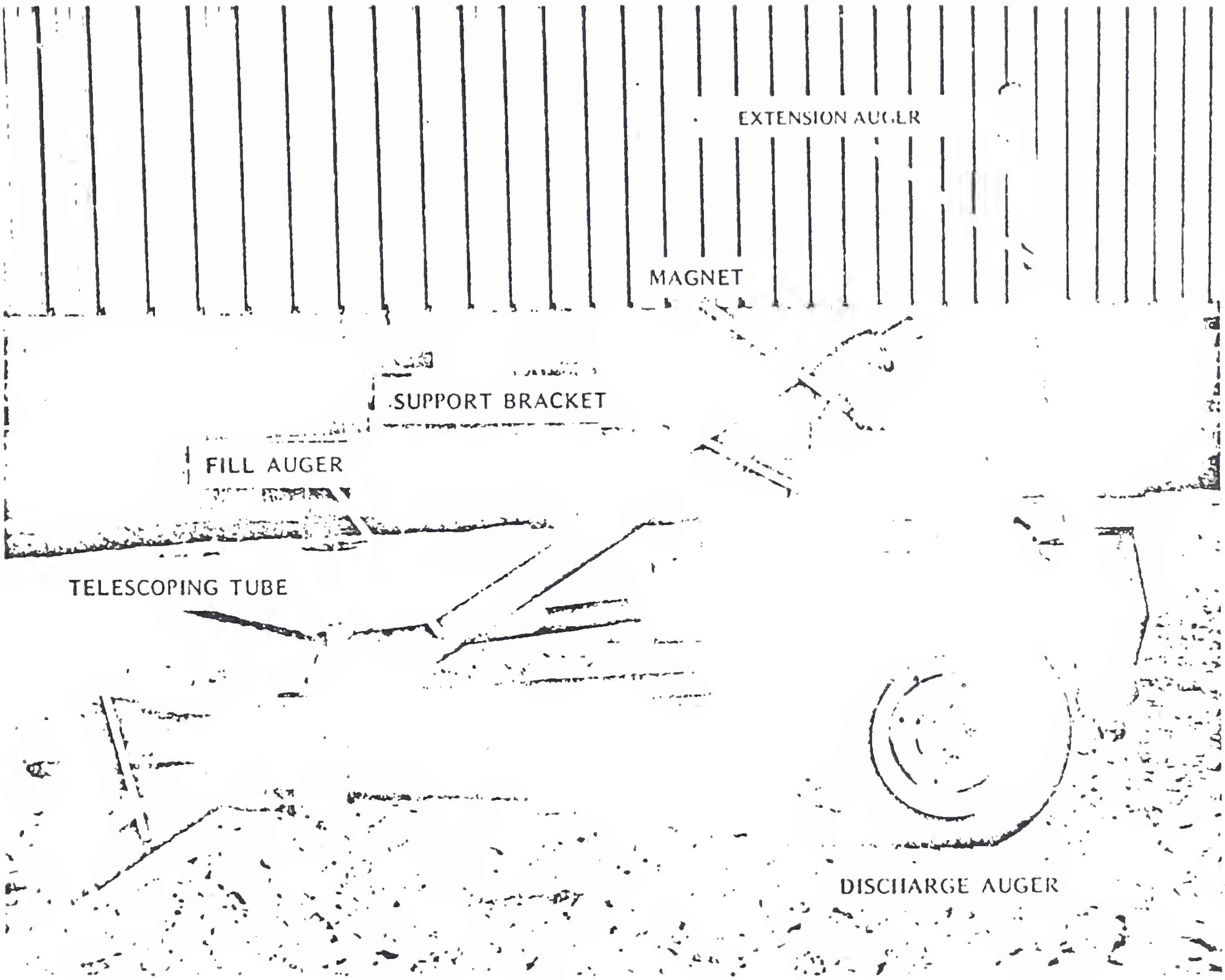
Before operating the BRADY 206 CROP COOKER check the machine thoroughly for these points.

1. Be sure the machine has been greased.
2. Be sure the belt tensions are correct.
3. Be sure no foreign object is in the hopper auger.

SAFETY SUGGESTIONS

Keep your hands, feet and clothing clear from all power-driven parts. Read the "Transporting" section carefully before transporting the 206 CROP COOKER.
Do not touch cylinder, discharge auger tube or extension tube while in operation for these components become very hot.
Keep all shields in place.
Never permit anyone to ride on the tractor drawbar or on the 206 CROP COOKER.
Always disengage the tractor P.T.O. before any adjustments or lubricating is done on the 206 CROP COOKER.

OPERATION



FILL AUGER

The hydraulically driven fill auger is equipped with a strong magnet to prevent metal from entering the extrusion chamber. When positioning the auger, always be sure the grain flow contacts this magnet before entering the hopper.

Grain flow rate into the hopper can be controlled to match the processing rate by sliding the telescoping tube at the inlet of the auger.

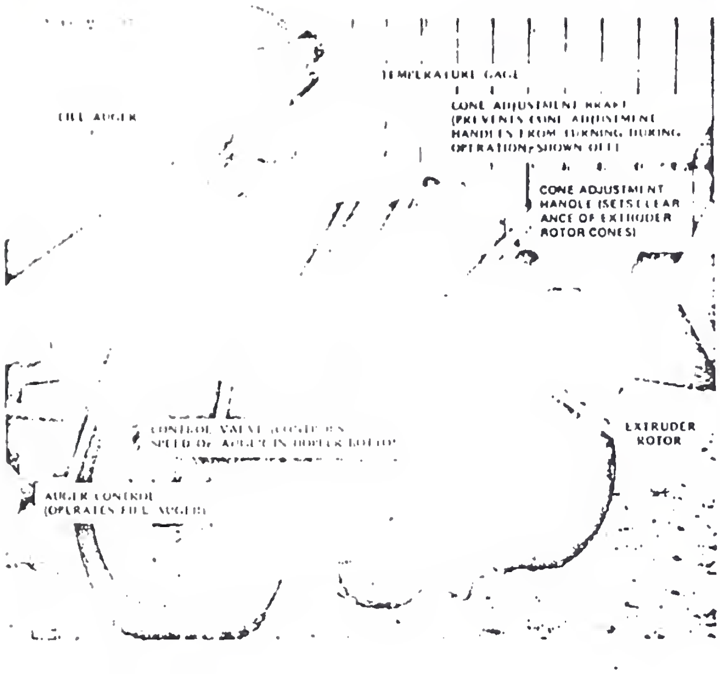
By positioning the fill auger support bracket at various positions on the hopper wall the auger can operate on either side or from the rear of the machine.

DISCHARGE AUGER

The discharge auger is reversible for right or left discharge. It comes from the factory set up for right discharge. For left discharge the auger mounts to the machine using the right discharge door brackets. For hose routing it is necessary to turn the hydraulic motor 180° for left discharge.

A safety lock pin is provided on the swivel bracket to insure holding the adjustment lever in the proper slot for operation or transport. The discharge auger swivels about the extruder cylinder for operation at different heights and is set in the vertical position for transport.

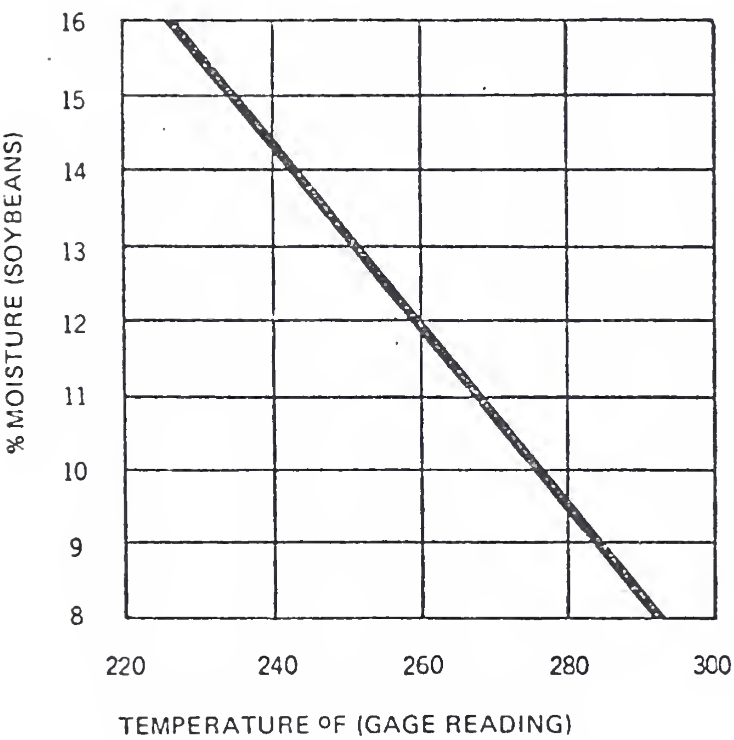
OPERATION



The Brady Crop Cooker is designed to operate with tractor power sources from 55 to 180 H.P. From 55 to 70 H.P. the machine operates best at 540 RPM P.T.O. speed. Above 70 H.P., 1000 RPM P.T.O. speed should be used.

The same machine operates at either speed. The only difference is the P.T.O. front half which adapts to the tractor spline.

The Brady Crop Cooker operates on the extrusion principle. Soybeans entering the hopper are augered toward the front of the machine by the injector auger and forced down into the extrusion chamber. The extruder rotor then augers the material to the rear and forces it out between the extruder cones. By controlling the cone clearances and input rate the processing temperature can be controlled. To increase the processing temperature, tighten the cones or reduce the control valve setting or both. To begin processing for most power sources, the cones should be set at ½ turn from tight. The most desirable setting to start varies however with tractor power and moisture content of soybeans. In general, more power and dryer beans requires the cones to be set tighter than less power and wetter beans.



The graph at left shows the relationship between processing temperature and moisture content of soybeans. Note that dryer soybeans should be cooked at higher temperatures than those of higher moisture content.

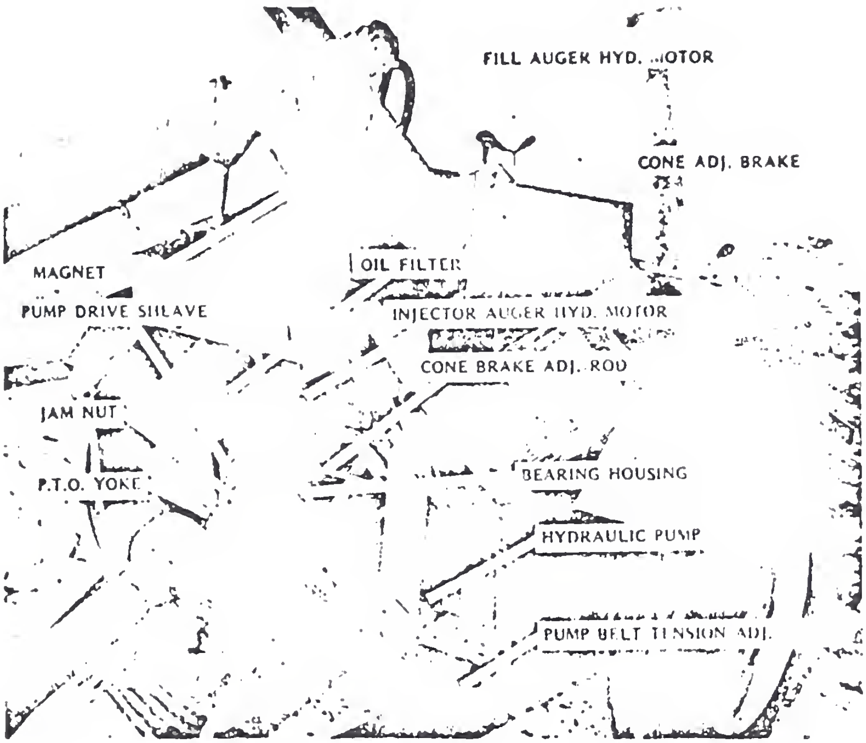
Example: 12% moisture soybeans should be cooked at 260° F.

TRANSPORTING

When transporting this unit on the highway follow these few instructions.

1. Place fill auger in the saddles provided for it and install lock pins to prevent auger from bouncing out of the saddles.
2. Place extension auger in saddles provided for it and also install lock pins to prevent auger from bouncing out.
3. Place lock pin behind the swivel handle to prevent discharge auger from falling.
4. Do not exceed 45 MPH when transporting this unit on the highway.

OPERATION



EXTRUDER ROTOR REMOVAL

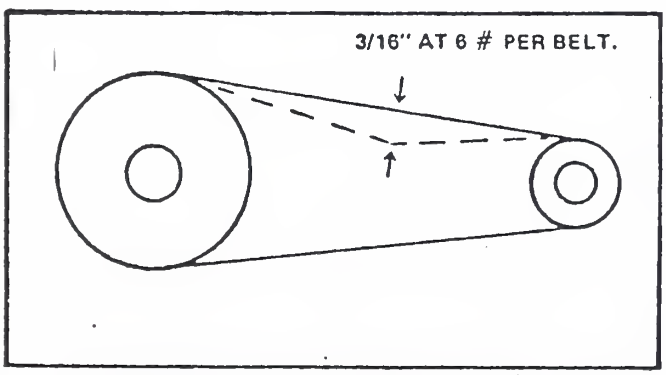
To remove the extruder rotor, remove the front shield and P.T.O. Then loosen the pump drive belts and remove the jam nut and pump drive sheave. The jam nut and pump drive sheave are threaded to the rotor with right hand threads. Use the sheave wrench provided with the machine and any large pipe wrench to remove this sheave.

It may be necessary to hold the rotor from turning by placing a bar thru the rear holes in the rotor. After the sheave is off, open the discharge auger door and push the rotor out the rear of the machine.

When replacing the rotor be sure and clean out the extruder cylinder to allow the rotor to freely slide forward until the step on the rotor shaft stops against the bearing housing. Also, when replacing the rotor the cones should be adjusted loose to allow the rotor to stop against the bearing housing and not against the cone surfaces.

CONE ADJUSTMENT BRAKE

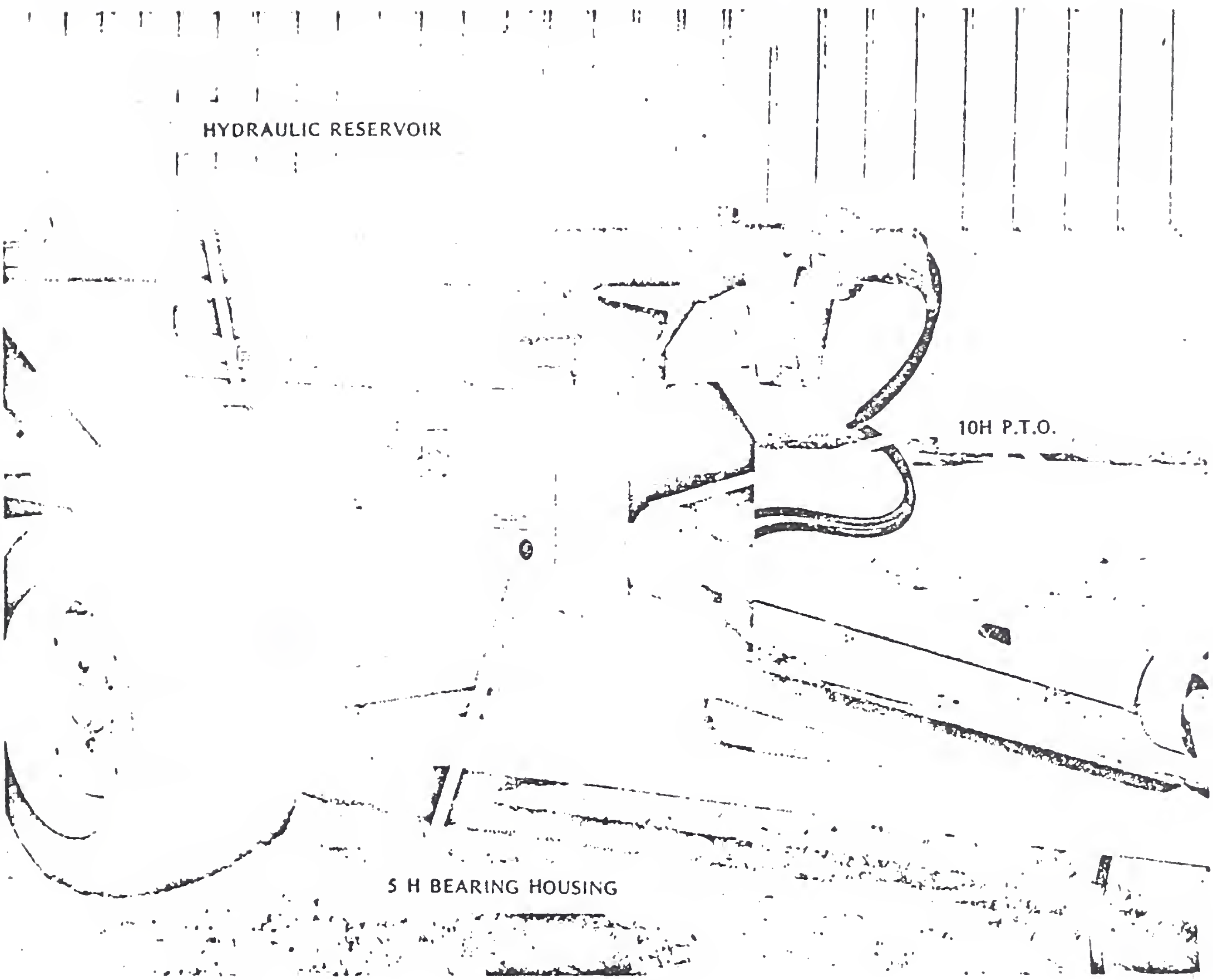
The cone adjustment brake keeps the bearing housing from turning and prevents the bearing housing from working in the threads which can cause excessive wear. For these reasons, the brake should always be engaged while operating. Occasional adjustment of the brake band tension may be required to hold the bearing housing firmly. Adjust this tension by turning the locknut on the cone brake adjusting rod.



PUMP BELT TENSION

The tension shown on the diagram for the two pump drive belts is accomplished by turning the nut on the pump belt tension adjustment rod. These belts must be kept quite tight to prevent slippage of the belts. If these belts slip, the hydraulic motors stall or run erratically.

LUBRICATION



LUBRICATION

The lubrication intervals for the various grease fittings are indicated by H, the number of hours of operation between applications. Lubricate these parts with several shots of SAE multi-purpose type grease. The period recommended is based on normal conditions: severe and unusual conditions may require more frequent lubrication. It may be necessary to turn cone adjustment handles at rear of machine to line up grease fitting in bearing housing with hole in front shield.

The wheel bearings should be repacked annually. The bearing housing threads and the cone adjustment shaft threads should be greased monthly or as required for smooth operation.

The three grease fittings (shown on page 13, Number 36) are to be greased also. Grease these fittings monthly or as required for smooth operation of the cone adjustment.

HYDRAULIC SYSTEM

The Model 206 CROP COOKER has a self contained open center hydraulic system factory tested and ready for operation. The reservoir level should be maintained at the mark on the dipstick, approximately 5 gallon capacity. An industrial hydraulic oil is used, BRADY part number 5100104. If this oil is not available, adequate performance can be obtained by substituting 5 gallons of type "A" automatic transmission oil. The oil and filter should be changed annually for normal use or at 6 month intervals for heavy use.

OPERATING TIPS

The Brady 206 Crop Cooker is designed to perform smoothly and efficiently. If difficulties still persist after following the operation instructions, use the following chart for problem, possible cause and remedy.

PROBLEM	POSSIBLE CAUSE	REMEDY
Tractor engine speed falls below normal PTO operating speed.	Over feeding or cooking too hot.	Reduce control valve setting or loosen cones.
Excessive vibration.	PTO misaligned.	Align PTO.
Cone adjustment handles hard to turn (brake off).	Threads on adjustment shaft or front bearing housing sticky or dry.	Clean threads and lubricate with grease.
Operating temperature too low.	Cones too loose or feed rate too fast.	Tighten cones or decrease feed rate.
Operating temperature too low. (Cones tight low feed rate.)	Tramp metal stuck to cone surfaces.	Remove rotor and chip metal burrs from cone surfaces.
Warms up too slowly.	Feed rate too high or cones too loose.	Decrease feed rate and run cones tighter during warm up.
Augers turn too slowly or stop.	Loose pump belts.	Tighten belts.
Injector auger won't turn, others turn slow (belts tight).	Cooker stopped with beans in hopper or in injector auger.	Break auger loose with pipe wrench on rear extension shaft.
Cone adjustment handles move during operation (brake on).	Loose brake band.	Tighten cone adjustment brake band.
Rotor locked (tractor killed).	Fed too fast.	Loosen cones, turn rotor backward four or five turns and restart.
Cones locked (can't loosen or turn rotor).	Operated too long without lubrication between cones.	Disassemble cones, turn rotor backwards, reassemble and restart.
Temperature fluctuates.	Dirty soybeans, many hulls.	Use cleaner soybeans.
Soybean meal turned brown and cakes in pile.	Meal left in original pile too long.	Move soybean meal once before long storage.

PART NUMBER REFERENCE

1051-12	20185-12	24024-14	26001-14	27084-9	30019-12	30082-14	30151-10
1057-12	20187-12	24026-14	26002-14	27100-9	30026-14	30084-14	30158-12
1058-12	23035-12	24028-14	26005-14	28528-12	30033-12	30086-12	30161-14
1063-12	23110-12	24045-14	26006-10	28614-10,12	30036-12	30090-12	30167-12
1088-12	23111-10,12	24054-14	26017-10	28615-14	30044-12	30091-14	30168-12
1089-12	23112-10,12	24056-14	26022-14	28622-12	30045-12	30093-12	30173-10
1090-12	23113-10,12	24069-14	26039-14	28623-14	30049-12	30095-10	30175-12
1117-12	23114-12	24070-14	26041-14	29256-12	30051-14	30096-10	30176-12
1674-12	23115-12	24083-14	27040-9	29501-9	30052-12	30100-10	30177-12
2125-12	23117-12	24084-14	27049-9	29533-12	30053-12	30101-10	30181-12
3290-10	24012-14	24086-14	27052-9	29536-9	30054-12	30102-12	30188-10
4105-10	24013-14	24087-14	27053-9	29574-10	30055-12	30103-12	30190-12
6041-12	24014-14	25022-14	27057-9	29575-14	30056-12	30106-10	30192-10
7051-12	24015-14	25024-10,14	27059-9	29576-14	30063-12	30127-12	30193-10
9049-14	24016-14	25027-14	27060-9	29577-14	30064-12	30129-12	30195-10
12357-9	24017-14	25049-12	27063-9	29578-14	30069-12	30138-10	30196-10
20115-12	24018-10,14	25060-14	27065-9	29581-14	30071-12	30141-10	30197-10
20143-14	24019-14	25092-10	27066-9	29582-14	30072-12	30142-10	30198-12
20181-12	24020-14	25103-14	27070-9	29583-14	30073-12	30145-10	30206-10
20182-12,14	24021-10,14	25104-14	27078-9	29584-14	30076-12	30146-10	30214-10
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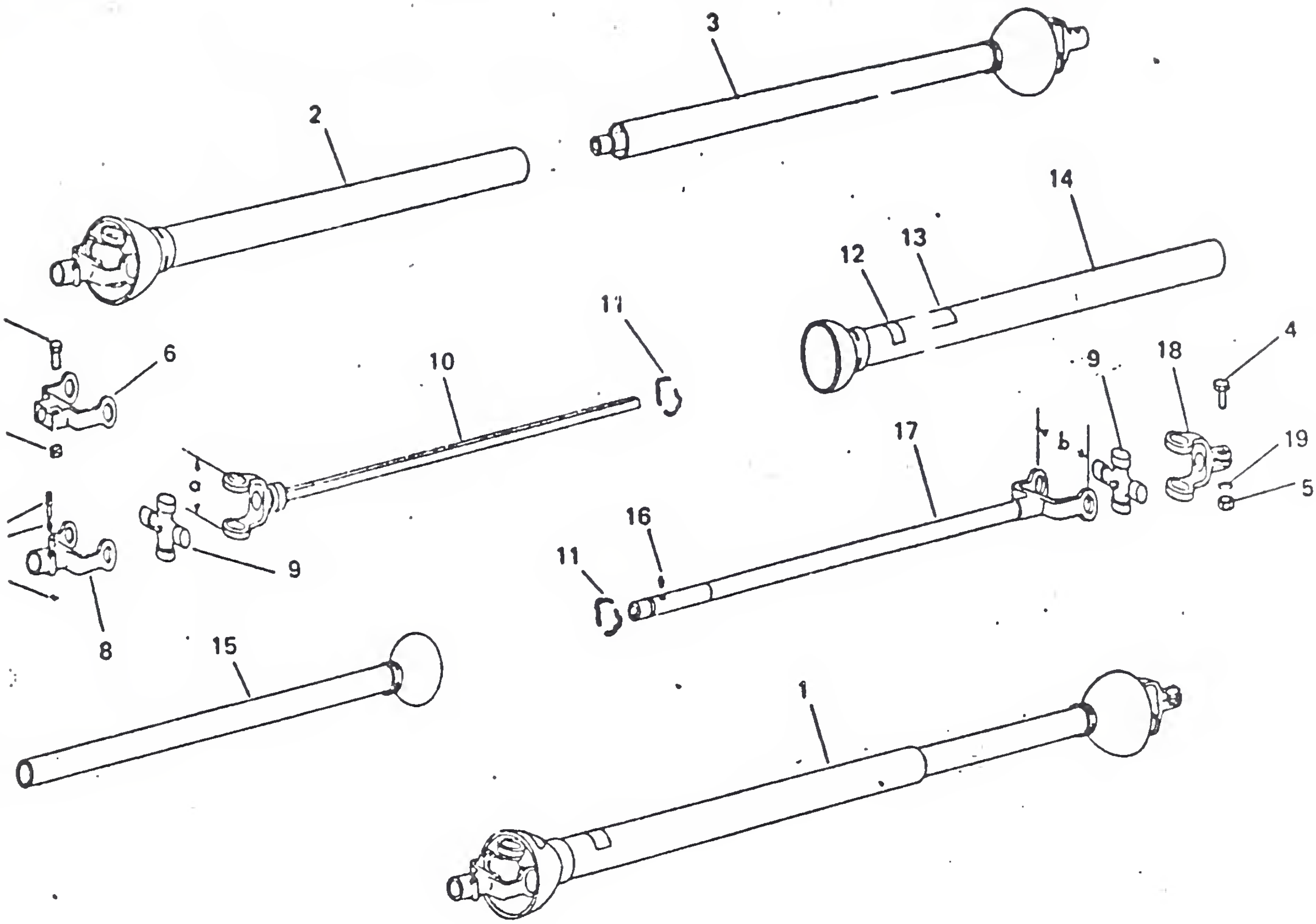
						30149-10	

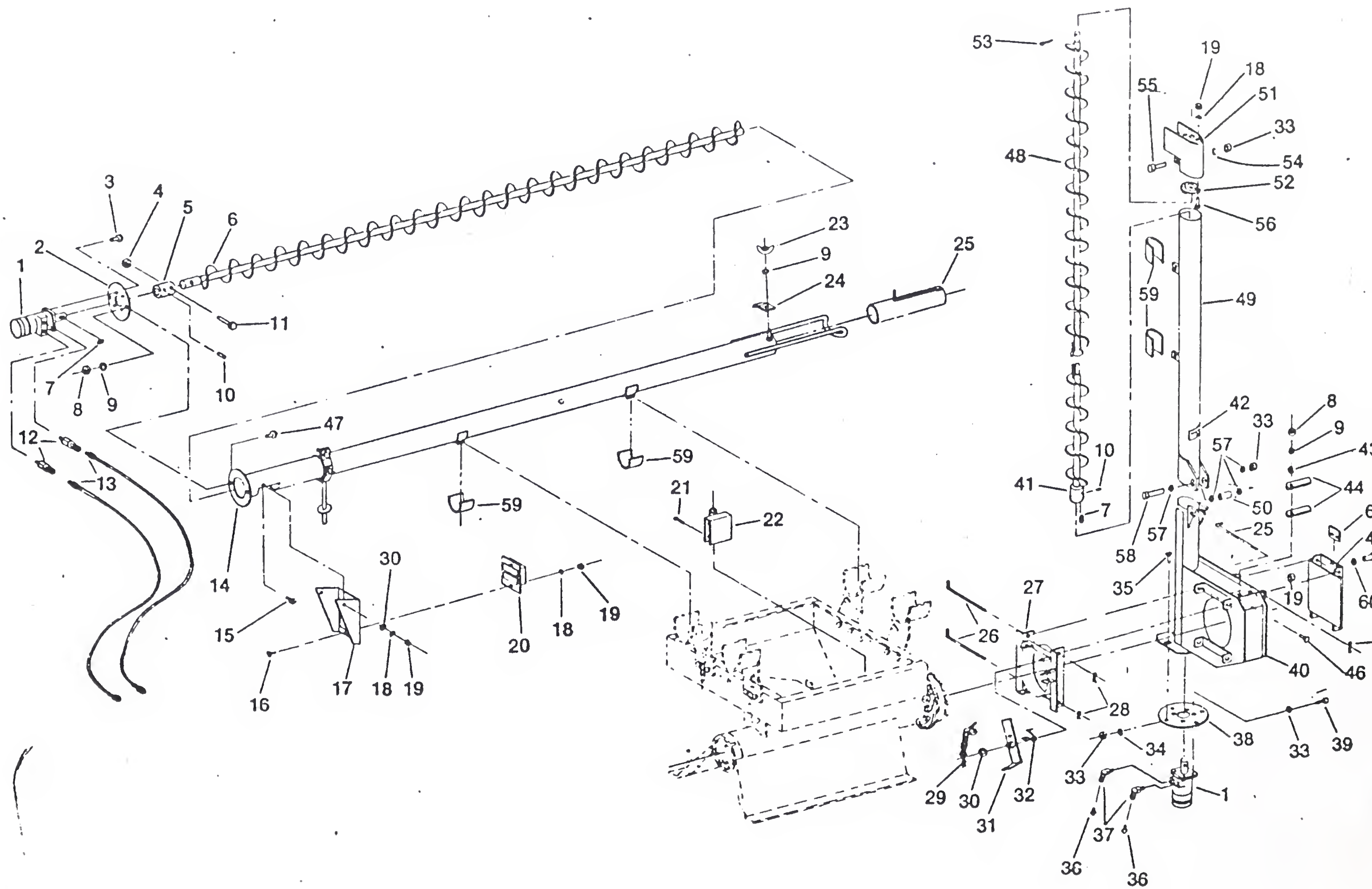


a = 4¼
b = 4¼

44R P.T.O. DRIVE SYSTEM

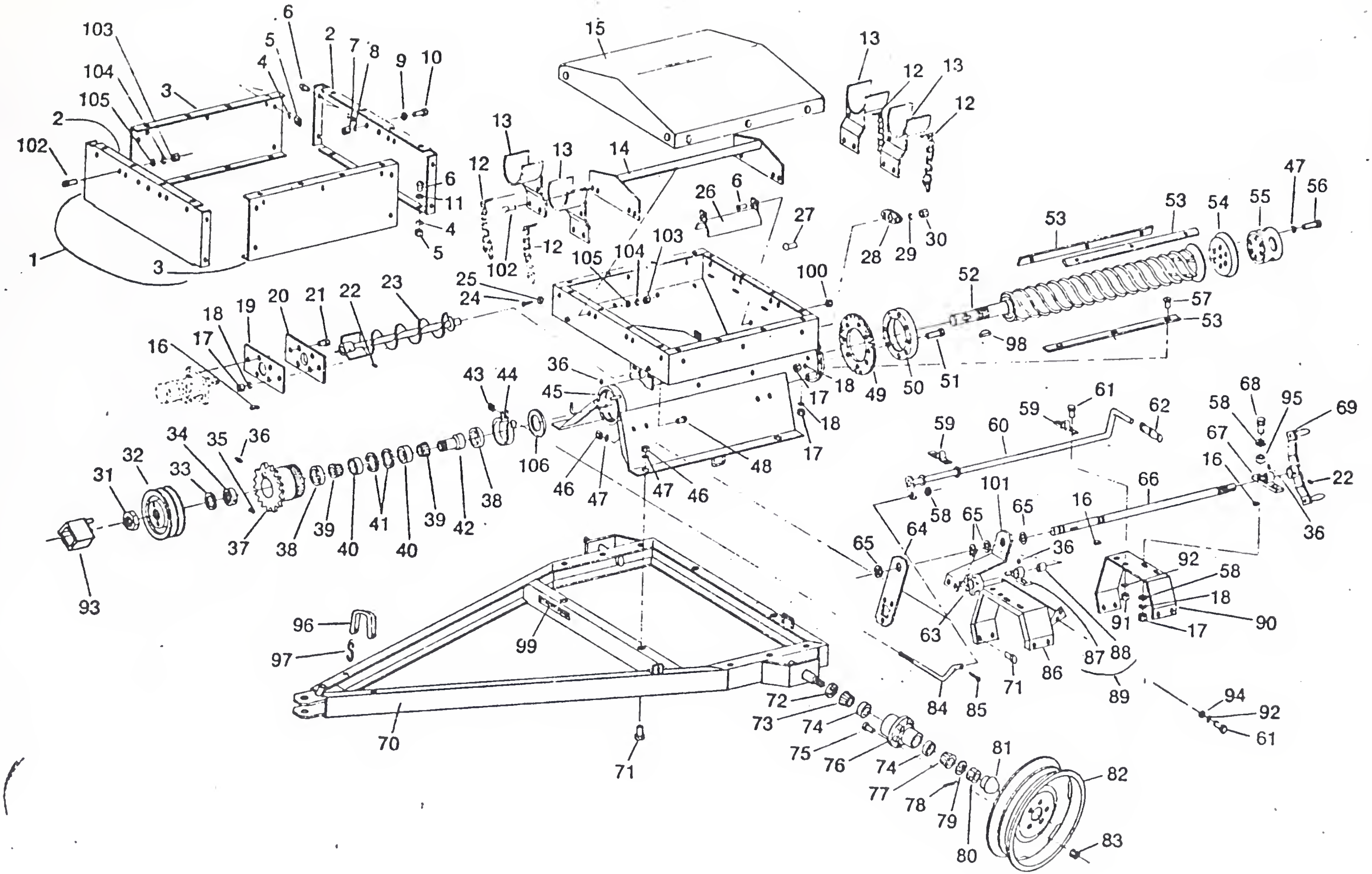
KEY	DESCRIPTION	QUAN.	540 R.P.M.	QUAN.	1000 R.P.M.
1	P.T.O. Complete	1	27100	1	27040
2	Front Half Assembly	1	27065	1	27059
3	Rear Half Assembly	1	27060	1	27060
4	½ NC x 3 HHCS Grd. 5 Pl.	1	3106211	2	3106211
5	½ NC Hex. Nut Pl.	1	3405105	2	3405105
6	1 3/8 - 21 Tooth Inv. Spline		--------	1	27049
7	Lock Pin Kit	1	27070		--------
8	1 3/8 6-B Spline Q.D. Yoke Asy.	1	27066		--------
9	Center Parts Kit	2	27057	2	27057
10	Yoke and Square Shaft	1	27053	1	27053
11	Shield Lock Brg. Half	2	27078	2	27078
12	Warning Decal	1	29536	1	29536
13	Warning Decal	1	29501	1	29501
14	Outer Shield and Bell Asy.	1	27084	1	27084
15	Inner Shield and Bell Asy.	1	27083	1	27083
16	Lube Fitting	1	12357	1	12357
17	Yoke, Tube and Sleeve	1	27052	1	27052
18	1½ Bore Clamp Yoke	1	27063	1	27063
19	½ Med. Lockwasher Pl.	1	3322013	1	3322013

KEY	DESCRIPTION	QUAN.	PART NO.
1.	Discharge Auger Hyd. Motor	2	26006
2.	Fill Motor Mount Plate	1	30106
3.	3/8 NC x ½ HHCS	4	3101101
4.	3/8 NC Stover LockNut	1	3400154
5.	Fill Auger Drive Hub	1	30096
6.	Fill Auger W.A.	1	30141
7.	No. 15 Woodruff Key ¼ x 1	2	3560025
8.	5/16 NC Hex Nut	3	3400102
9.	5/16 Med. Split L.W.	4	3321010
10.	3/8 NC x 3/8 Soc. Hd. S.S.	3	3123042
11.	3/8 NC x 2¼ HHCS	1	3101110
12	3/8 F x ½ M Str. Swivel Adapt.	2	24021
13.	61 in. x 3/8 NPT Hyd. Hose	2	25024
14.	Fill Auger Tube W.A.	1	30145
15.	¼ NC x ½ Rd. Hd. Slotted Screw	4	3110654
16.	¼ NC x ¾ Rd. Hd. Slotted Screw	2	3110657
17.	Fill Auger Spout	1	30100
18.	¼ Med. Split L.W.	5	3321009
19.	¼ NC Hex Nut	7	3400101
20.	Magnet	1	30173
21.	3/8 NC x 1½ Sq. Hd. Set Screw	4	3121034
22.	Auger Swivel Support W.A.	1	30149
23.	5/16 NC Wing Nut	1	4105
24.	Slide Clamp	1	30101
25.	Adjustment Slide W.A.	1	30142
26.	Hinge Rod	3	30138
27.	Discharge Swivel Weld.	1	30151
28.	No. 3 Hair Pin Clip	3	9049
29.	¼ Lock Pin	1	28614
30.	½ Std. Flat Washer	3	3301010
31.	Swivel Handle W.A.	1	30146
32.	Torsion Spring	1	3290
33.	3/8 NC Hex Nut	6	3400103
34.	3/8 Std. Flat Washer	8	3301008
35.	3/8 NC x 1 Cge. Bolt	4	3011068
36.	TP-5, 3/8 - 18 Thd. Pipe Plug	2	26017
37.	½ x 3/8 x 45° Swivel Adapt.	2	24018
38.	Flexible Coupling	1	25092
39.	3/8 NC x 1 HHCS	4	3101105
40.	Discharge Tube W.A.	1	30193
41.	Discharge Auger W.A.	1	30192
42.	Warning Hot Decal	1	29574
43.	5/16 Std. Flat Washer	1	3301007
44.	Flat Spring	2	30095
45.	Rear Door W.A.	1	30147
46	5/16 NC x 1 Cge. Bolt	1	3011042
47	5/16 NC x ¾ HHCS	2	3101053
48.	Extension Auger Weld.	1	30195
49.	Extension Tube Weld.	1	30196
50.	Hinge Pipe	1	30206
51.	Extension Hood Weld.	1	30197
52.	5/8 Flangette Brg.	1	23113
	Insert	1	23112
	Flange	2	23111
53.	1/8 x 1 Cotter Pin	1	3540023
54.	3/8 Med. Lock Washer	1	3321011
55.	3/8 NC x 1 3/4 HHCS	1	3101108
56.	1/4 NC x 3/4 Cge. Bolt	1	3011019
57.	3/8 Internal Tooth L.W.	4	3331011
58.	3/8 NC x 5 HHCS	1	3101119
59.	Fill Auger Cushion	4	30188
60.	¼.std. Flat washer	2	3301006
61.	Tension Slide Plate	1	30214



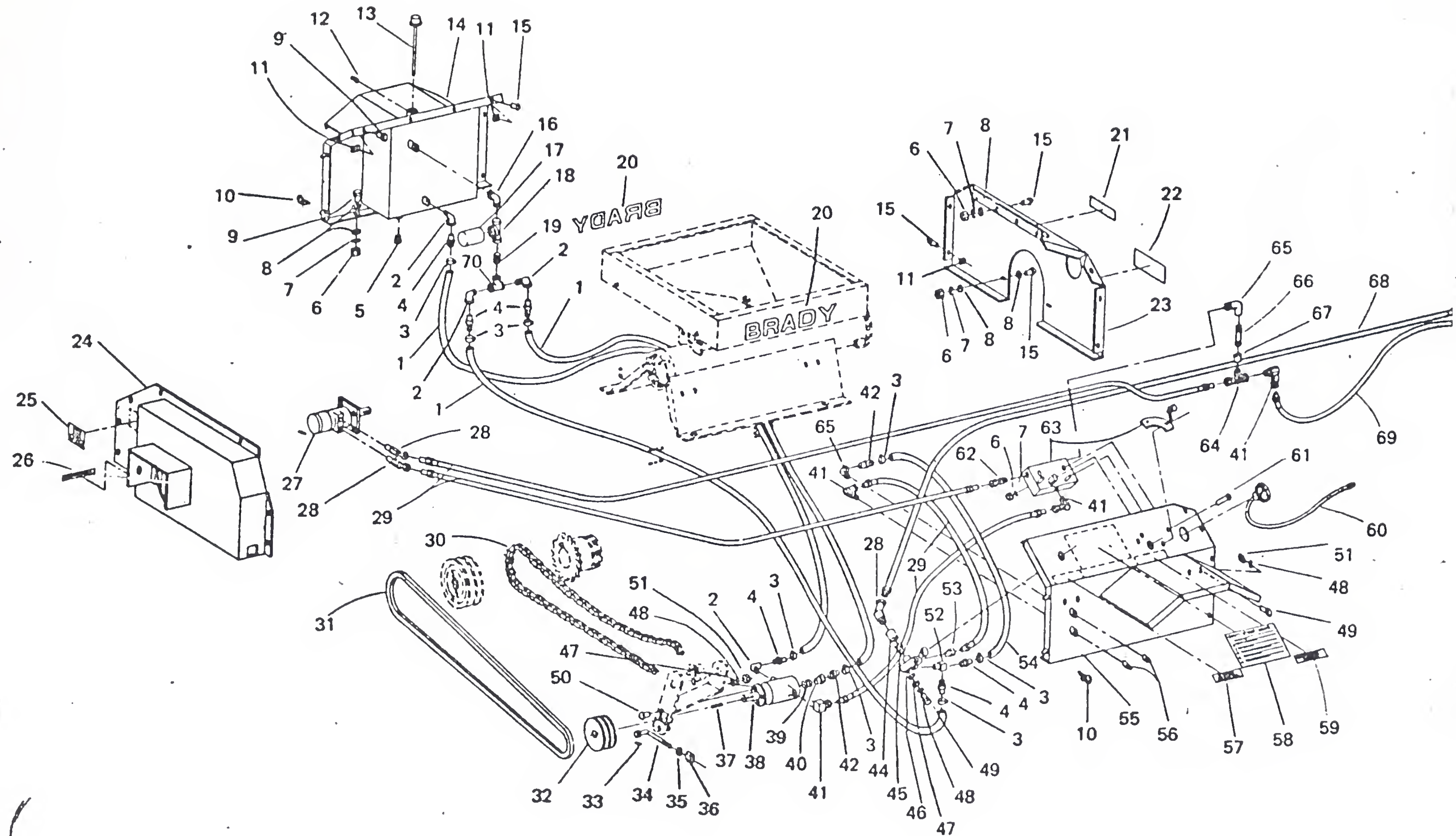
FILL AUGER, DISCHARGE AND EXTENSION AUGER

KEY	DESCRIPTION	QUAN.	PART NO.
1	Hopper Extension Bundle (Optional)	1	2125
2	Extension End Plate	2	30103
3	Extension Side Plate	2	30102
4	¼ Med. Split Lockwasher Pl.	23	3322009
5	¼ NC Hex. Nut Pl.	23	3405101
6	¼ NC x ¾ Rd. Hd. Slotted Pl.	26	3110657
7	5/16 NC Hex. Nut Pl.	4	3405102
8	5/16 Med. Split Lockwasher Pl.	4	3322010
9	5/16 Std. Flat Washer Pl.	4	3302007
10	5/16 NC x ¾ HHCS Pl.	4	3102053
11	¼ Std. Flat Washer	16	3302006
12	¼ Lock Pin	4	28614
13	Auger Saddle Weldment	4	30079
14	Cover Support Weldment	1	30198
15	Tarp	1	30176
16	No. 15 Woodruff Key ¼ x 1	3	3560025
17	3/8 NC Hex. Nut	23	3400103
18	3/8 Med. Split Lockwasher	23	3321011
19	Motor Base Plate	1	30055
20	Motor Cushion	1	30056
21	3/8 NC x ½ HHCS	4	3101101
22	3/8 NC x 3/8 Soc. Hd. Set Screw	2	3123042
23	Injector Auger Weld. Asy.	1	30073
24	No. 6 x ½ Pan Hd. Tapping Screw	10	20187
25	Snap (Male Half)	10	30177
26	Auger Cover Weldment	1	30076
27	¼ NC x ¾ Cge. Bolt	2	3011019
28	5/8 Flangette Bearing	1	23113
	5/8 Bearing Insert	1	23111
	Bearing Flange	2	23112
29	¼ Med. Split Lockwasher	2	3321009
30	¼ NC Hex. Nut	2	3400101
31	1 3/4 UN-12 Hex. Jam Nut	1	20181
32	Drive Sheave	1	28622
33	1¾ Washer	1	6041
34	Bearing Retaining Nut	1	30129
35	¼ NC x ¼ Soc. Hd. Set Screw	1	3123014
36	Grease Fitting	4	20115
37	Bearing Housing Weldment	1	30157
38	Seal	2	23117
39	Bearing Cup	2	23115
40	Bearing Cone	2	23114
41	Snap Ring	2	20184
42	Bearing Inner Housing	1	30127
43	3/8 NC Stover Locknut	1	3400154
44	Brake Band Assembly	1	30168
45	Cylinder Hopper Weldment	1	30019
46	½ NC Hex. Nut	8	3400105
47	½ Med. Split Lockwasher	14	3321013
48	3/8 NC x 1 Cge. Bolt	2	3011068
49	Swivel Ring	1	30093
50	Processor Cup	1	30044
51	3/8 NC x 2¼ HHCS	8	3101110
52	Rotor Weldment Complete	1	30036
53	Cylinder Rib	3	30063
54	Processor Cone	1	30045
55	Cone Collar Weldment	1	30158
56	½ NC x 2¼ HHCS	6	3101208
57	3/8 NC x 1¼ Plow Bolt	9	3071004
58	3/8 Std. Flat Washer	9	3301008
59	Brake Rod Bracket	2	30049
60	Brake Rod Weldment	1	30033
61	5/16 NC x ¾ HHCS	6	3101053
62	¾ in. Rubber Fluted Grip	1	25105
63	1¼ Alignment Sprocket	1	28528
64	Pump Mount Plate	1	30053
65	Snap Ring	4	20185
66	Adjustment Rod	1	30064
67	Adj. Rod Nut Weldment	1	30071
68	3/8 NC x 1¼ HHCS	4	3101106
69	Adj. Cross Bar Weldment	1	30069
70	Frame Weldment	1	30000
71	½ NC x 1 HHCS	8	3101203
72	Seal	2	23035
73	Inner Bearing	2	1058
74	Bearing Race	2	1051
75	½ - 20 x 1½ NF Lug Bolt	10	1089
76	Hub Assembly (with Races & Bolts)	2	1088
	Hub (without Races & Bolts	2	1674
77	Outer Bearing	2	1057
78	5/32 x 1½ Cotter Pin	2	3540034
79	¾ Std. Flat Washer	2	3301013
80	¾ NF Hex. Slotted Nut	2	3401136
81	Hub Cap	2	1063
82	14 x 6 Wheel	2	7051
	15 x 6 Wheel	2	1117
83	½ NF Hub Lug Nut	10	1090
84	Brake Adjustment Rod	1	30052
85	1/8 x 1 Cotter Pin	1	3540023
86	Rod Front Support Weld.	1	30086
87	Adj. Rod Bearing Weldment	1	30072
88	Bronze Bushing	1	23110
89	Adj. Rod Bearing Assembly	1	30167
90	Adj. Rod Rear Support	1	30090
91	5/16 NC Hex. Nut	4	3400102
92	5/16 Med. Split Lock Washer	6	3321010
93	Sheave Wrench	1	30175
94	5/16 Std. Flat Washer	2	3301007
95	Spacer	4	30181
96	9 in. Rubber Strap	1	25049
97	"S" Hook	2	29256
98	No. 29 Wdrf. Key 3/8 x 2 1/8	1	3560053
99	Patent Pend. Decal	1	29533
100	Nut Retainer	1	20182
101	Pump Mount Brace	1	30054
102	3/8 NC x 1 HHCS Pl	16	3102105
103	3/8 NC Hex Nut Pl	16	3405103
104	3/8 Med. Split L.W. Pl	16	3322011
105	3/8 Std. Flat Washer Pl.	16	3302008
106	Flinger	1	30190



FRAME AND CYLINDER ASSEMBLY

KEY	DESCRIPTION	QUAN.	PART NO.	KEY	DESCRIPTION	QUAN.	PART NO.
1	45 in. x ½ in. Low Pressure Hose	3	25022	36	3/8 NC Stover Lock Nut	1	3400154
2	½ x 90° Street Elbow	4	24087	37	1/8 x 1/8 x 1 Key	1	20143
3	¾ Hose Clamp	8	24012	38	Hydraulic Pump	1	26039
4	½ Hose Barb	6	24015	39	¼ Close Nipple	1	24083
5	½ Pipe Plug	1	24026	40	3/8 x ¼ Reducer Coupling	1	24084
6	¼ NC Hex. Nut	12	3400101	41	3/8 x 90° Swivel Adaptor	4	24019
7	¼ Med. Split Lock Washer	12	3321009	42	3/8 x ½ Hose Barb	2	24045
8	¼ Std. Flat Washer	20	3301006	44	½ Coupling	1	24054
9	¼ NC x ¾ HHCS	8	3101004	45	½ Short Nipple	1	24014
10	No. 3 Hair Pin Cotter	7	9049	46	Selector Valve	1	26022
11	Nut Retainer	14	20182	47	5/16 Std. Flat Washer	8	3301007
12	¼ Relief Valve	1	24028	48	5/16 Med. Split Lockwasher	10	3321010
13	Dipstick Weldment	1	30161	49	5/16 NC x ¾ HHCS	6	3101053
14	Reservoir Weldment	1	30026	50	5/16 NC x 1 Cge. Bolt	4	3011042
15	¼ NC x ¾ Rd. Hd. Slotted	18	3110657	51	5/16 NC Hex. Nut	8	3400102
16	¾ x 90° Street Elbow	1	24013	52	½ Service Tee	1	24024
17	Filter Element	1	52000	53	½ m x 3/8 f Str. Swivel Adaptor	1	24021
18	Filter Complete	1	26001	54	23 in. x ½ Low Pressure Hose	1	25103
19	¾ Close Nipple	1	24017	55	Left Side Shield Weldment	1	30084
20	Brady Decal	2	29582	56	3/8 Pipe Plug	2	24086
21	Cone Adj. Brake Decal	1	29578	57	Auger Control Decal	1	29577
22	Tighten Cone Adj. Decal	1	29575	58	Operating Inst. Decal	1	29583
23	Rear Shield	1	30082	59	Control Valve Decal	1	29576
24	Front Shield Weldment	1	30091	60	Temperature Gauge	1	26041
25	Koehring Decal	1	29581	61	¼ NC x 2¼ Rd. Hd. Slotted	2	3110665
26	Lubricate Decal	1	29584	62	3/8 Straight Swivel Adaptor	1	24020
27	Unloading Auger Hyd. Motor	1	26005	63	Full Control Valve	1	26002
28	½ x 3/8 45° Swivel Adaptor	3	24018	64	3/8 Swivel Tee	1	24022
29	3/8 I.D. x 23 in. Hyd. Hose	4	25060	65	3/8 x 90° Street Elbow	2	24070
30	No. 50 Roller Chain	1	28623	66	3/8 x 3 in. Nipple	1	24069
31	"A" Section Belt Set	1	25104	67	3/8 Pipe Coupling	1	24056
32	3 1/8 P.D. 2-"A" Groove Sheave	1	28615	68	3/8 x 61 in. Hyd. Hose	1	25024
33	¼ NC x ½ Soc. Hd. Set Screw	2	3123018	69	3/8 x 45 in. Hyd. Hose	1	25027
34	Belt Draw Bolt	1	30051	70	½ x ½ x ¾ Side Port Tee	1	24016
35	3/8 Std. Flat Washer	1	3301008				



HYDRAULIC SYSTEM

BRADY PRODUCTS WARRANTY

"Brady warrants its equipment to be free from defects in material or workmanship, under normal and proper use in accordance with instructions of Brady for a period of ninety (90) days from date of delivery to the buyer, but the liability on such warranty shall be limited to the repair or replacement by Brady (f.o.b. Des Moines, Iowa) of any of its equipment which may be returned by the buyer to Des Moines, Iowa, transportation charges and handling fees prepaid, within said ninety (90) day period and which is found by Brady to have been defective in material or workmanship.

The foregoing is the full extent of the responsibility of Brady. There are no other warranties, express or implied, and in no event shall Brady be liable for delay caused by defects, for consequential damages, or for any charges or expense of any nature incurred without its written consent. This warranty will not apply to any product which has been repaired or altered outside of our Plant, in any respect which, in our judgment, affects its condition or operation."

In accordance with our established policy of constant improvement, we reserve the right to amend these specifications at any time without notice. THE ONLY WARRANTY APPLICABLE IS OUR STANDARD WRITTEN WARRANTY. WE MAKE NO OTHER WARRANTY, EXPRESSED OR IMPLIED, AND PARTICULARLY MAKE NO WARRANTY OF SUITABILITY FOR ANY PARTICULAR PURPOSE.

KOEHRING

Koehring
Farm Division
Des Moines, Iowa 50305

APPENDIX E

Typical Operating Costs for Brady Crop-Cooker

a) Production Rate

$$2{,}000 \frac{\text{lbs.}}{\text{hr.}} \times 1{,}000 \frac{\text{hours}^{*}}{\text{year}} = 2{,}000{,}000 \frac{\text{lbs}}{\text{yr.}} \text{ or } 1{,}000 \text{ tons/year}$$

b) Fixed Costs

1. Depreciation - $15,000/5 years = $3,000 or $3.000/ton.
2. Taxes and insurance = $500 or $0.5/ton.

Total fixed costs = $3.50/ton

c) Variable costs (excluding raw materials, inventory costs, and product losses).

1. Labor - one laborer @ 0.50/hr. x 2,000 hours/yr** = $1,000 or = $1.00/ton
2. Supervision - 25% of labor = 0.25/ton
3. Overhead - 50% of labor = 0.50/ton
4. Power - $0.02/h.p.-hr. x 100 h.p.-hr/ton = $2.00/ton
5. Maintenance (conservative estimated based on manufacturers experience) = $1.00/ton

Total variable costs = $4.75

d) Total Costs (fixed plus variable)

3.50 + 4.75 = $8.25 or $10/ton (0.5¢/lb.)

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* (50% of one shift)

** (100% of one shift)

APPENDIX F

TRIP REPORT - Brady Division, Koehring Company

Des Moines, Iowa
March 31, 1972

Summary

Preliminary tests of the suitability of cooking whole and dehulled soybeans, mixtures of degermed corn meal and dehulled soybeans, and degermed corn meal with a Brady Crop-Cooker were undertaken. Although no satisfactory operating conditions were found for cooking degermed corn meal, the operability of the machine was demonstrated for all other materials. Products from the tests will be evaluated chemically and functionally by ARS (Northern Regional Laboratories, Peoria), ADM, and Kansas State University. If the properties of the cooked products are satisfactory, it is expected that the Brady Crop-Cooker will find application in LDCs for manufacture of soy ingredients and blended food products and thereby, provide a source of low-cost nutritional foods.

Participants: Marvin Van Perusam, General Manager, Brady
Gus Mustakus, USDA/ARS
Paul Klienfelter, Central Iowa Bean Mill
Rod Crowley, USDA/ERS

One of the key nutrition problems identified by the USAID Office of Nutrition is the lack of availability of low cost nutritional foods in LDCs. A number of LDCs are attempting to overcome this problem impart by utilizing soybean protein products as ingredients for fortified staple foods and other nutritionally improved foods. In order to so use soybeans, a means of converting soybeans to edible flours or other food-grade products must be available within the LDCs. Furthermore, the means of processing should be relatively low in cost, simple to operate, and adaptable to the special conditions prevailing in LDCs. The purpose of this trip was to undertake preliminary tests of a soybean processing devise, the Brady Crop-Cooker, which potentially satisfies these requirements.

Brady Crop Cooker

The Brady Crop-Cooker is a low-cost extrusion-cooking machine manufactured by the Brady Division of Koehring Company, Des Moines, Iowa, for use by farmers

and feed manufactures to cook whole soybeans prior to incorporation in mixed feeds. The machine cooks soybean by mechanically working the beans and raising their temperature with the heat resulting from friction and, thereby, inactives the trypsin inhibiting enzymes. The soybean product so produced is a soybean meal containing all the components of whole soybean but in a fully-cooked condition suitable for animal feeding.

The crop-cooker is manufactured either as a unit to be driven by connection to the power-take-off of an ordinary farm tractor (Model 206) or as a complete electrically driven unit (Model 2160). (Brochures for both units are attached.) Neither unit requires any additional accessories or other services (gas, air or water) in order to produce fully-cooked soybeans. The tractor driven unit costs $3,125 and the electrically driven unit, complete with 100 h.p. motor, costs $6,500. Both units have capacities of approximately 2,000 lbs. per hour based on 100 h.p. delivered to the shaft. Furthermore, the units are extremely easy to operate and control; the machines are designed for operation by unskilled labor with a minimum amount of instructions.

Purpose of Tests

In view of the low-cost, high capacity, and simplicity of operation of the Crop-Cooker, it was believed that this machine might be suitable for use in LDCs for manufacture of food-grade soy products. Also because of the design and operating characteristics of the machine, it was believed that it might be suitable for cooking mixtures of soy and cereals to make blended foods (similar to CSM) and cereal grains alone to make pre cooked cereals (similar to processed corn meal). The subject tests were undertaken for the purpose of

evaluating in a preliminary way these possibilities.

Raw Materials

The following raw materials were used in the tests

1. Whole soybeans,
2. Dehulled soybeans
3. Degermed corn cones (fine grits)

In addition, a mixture containing 70% degermed corn cones and 30% dehulled soybeans was prepared by hand mixing at Brady.

Tests

The raw materials were processed through a Model 206 crop-cooker driven by a farm tractor which was capable of delivering approximately 100 h.p. to the machine. Both the whole beans and dehulled beans were processed at three temperature conditions to provide a range of product properties. The mixture of corn and soy was processed at two temperature conditions. No stable operating conditions could be identified during the tests under which the corn cones could be cooked.

Approximately 25-50 lbs. of product from each successful test run were collecte Sample identification and test conditions for these products were as follows:

Raw Material	Sample No.	Temperature	Throughput
Whole Soy	W-288	288°F	1480 lb/hr.
"	W-278	278°F	1360 " "
"	W-260	260°F	1130 " "
Dehulled Soy	D-283	280°F	2430 " "
"	D-252	252°F	2080 " "
"	D-240	240°F	1680 " "
Corn-Dehulled Soy	CS-310	310°F	1210 " "
"	CS-330	330°F	1320 " "